NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

THESIS

AN EXPERIMENTAL INVESTIGATION OF THE IMPACT OF CONFLICTING PROJECT GOALS ON STAFF RESOURCE ALLOCATION

by

Clinton L. Swett

June, 1995

Co-Advisors: Tarek Abdel-Hamid
Kishore Sengupta

Approved for public release; distribution is unlimited.

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE June 1995.	3. REPORT TYPE AND DATES COVERED Master's Thesis, Final

4. TITLE AND SUBTITLE An Experimental Investigation of the Impact of Conflicting Project Goals on Staff Resource Allocation	5. FUNDING NUMBERS
6. AUTHOR(S) Clinton L. Swett	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey CA 93943-5000	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.	12b. DISTRIBUTION CODE

13. ABSTRACT *(maximum 200 words)*

The Department of Defense Information Technology budget stands at nine billion dollars and is under severe scrutiny while the backlog of required software continues to grow. It is thereby necessary to improve the efficiency of managing the software process. This thesis uses the Systems Dynamic Model of Software Project Management to investigate the effects of stated goals on project manager behavior. Specifically, the experiment focuses on how software project managers allocate resources in both relaxed and constrained resource environments. The effect of goals on manager performance are measured in terms of staffing level decisions, percent of staff allocated to quality assurance activities, estimated schedule, and estimated cost. The results show that manager performance is highly sensitive to stated goals.

14. SUBJECT TERMS Software, Software Project Management, System Dynamics, Simulation	15. NUMBER OF PAGES 140
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18 298-102

Approved for public release; distribution is unlimited.

AN EXPERIMENTAL INVESTIGATION OF THE IMPACT OF CONFLICTING PROJECT GOALS ON STAFF RESOURCE ALLOCATION

Clinton L. Swett
Captain, United States Marine Corps
B.S., Southern Illinois University, 1984
M.B.A., National University, 1993

Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
June 1995

Author: Clinton L. Swett

Clinton L. Swett

Approved by: T. Hamid

Tarek Abdel-Hamid, Co-Advisor

Kishore Sengupta

Kishore Sengupta, Co-Advisor

D. R. W.

David R. Whipple, Chairman
Department of Systems Management

ABSTRACT

The Department of Defense Information Technology budget stands at nine billion dollars and is under severe scrutiny while the backlog of required software continues to grow. It is thereby necessary to improve the efficiency of managing the software process. This thesis uses the Systems Dynamic Model of Software Project Management to investigate the effects of stated goals on project manager behavior. Specifically, the experiment focuses on how software project managers allocate resources in both relaxed and constrained resource environments. The effect of goals on manager performance are measured in terms of staffing level decisions, percent of staff allocated to quality assurance activities, estimated schedule, and estimated cost. The results show that manager performance is highly sensitive to stated goals.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

The Department of Defense (DOD) spends big money each year on computer software. Currently, the Information Technology budget stands at nine billion and is under severe scrutiny while the backlog of required software continues to grow. It is thereby necessary to improve the efficiency of managing the software process.

Prior research suggests that programmers are goal driven. In a 1974 paper, (Weinberg and Schulman, 1974) showed that programming team performance is highly sensitive to given objectives. The paper showed that each team finished best with respect to the objective they were asked to optimize. The results also showed that none of the teams performed consistently well on all of the objectives. Two important conclusions have been drawn from this research. First, that programmers have very high achievement motivation. Second, that different software objectives are in conflict with each other.

B. PURPOSE OF RESEARCH

The purpose of this thesis is to design, develop, and conduct an experiment using the Systems Dynamic Model (SDM) of Software Project Management developed in (Abdel-Hamid and Madnick, 1991) to investigate whether managerial goals (i.e. schedule, cost, and quality) will also have a significant influence on managerial behavior and project outcome. Specifically, this research will investigate the impact of different schedule, cost, and quality goals on managerial decisions in allocating staff resources, and whether this leads to significant differences in project outcomes. Even though research has been conducted into the affect of goals on programmers in the Weinberg and Schulman experiment, no study on the affects of goals on project managers using this type of tool has been published.

C. SCOPE OF RESEARCH

The scope of this research is the design, construction, and conduct of an experiment using the Systems Dynamic Model of Software Project Management to

analyze the effects of conflicting goals on software project managers. The Systems Dynamics Model of Software Project Management will be used to simulate the programming phase of an actual software project. Graduate students, representing software managers, will be divided into four groups and will be asked to make staffing decisions for their project every 40 days throughout the programming phase of the project life cycle.

The four groups represent different combinations of project size and goal sets and will be designated as groups A1, A2, B1, and B2. The letter will indicate the project to be managed. Project A will be initially underestimated in size and grow throughout the programming phase. Project B will be initially overestimated and will decrease in size throughout the programming phase. The number indicates the goal set. Goal set 1 is cost and schedule. Goal set 2 is quality and schedule.

Data will be collected on several dependent variables after each 40 day period. This data will then be statistically analyzed to determine differences in decision making performance among the groups. The experiment will seek to investigate the following research questions: 1. What degree of influence do project goals have on a software project manager's staffing decisions? 2. How will a project manager allocate resources in both constrained and relaxed resource environments?

D. LIMITATIONS

The participants for this experiment were graduate students in their fifth quarter of an eight quarter graduate program leading to a MS degree in Information Technology Management at the Naval Postgraduate School in Monterey, California. Although these students are not actual software managers, they have received extensive education in software design and management. Their experience as managers in a myriad of military specialities to date lends credibility to the assumption that the results would be representative of the software industry. This assumption is further supported by the findings of William Remus. (Remus, 1986)

E. THESIS ORGANIZATION

Chapter II describes the required software files, and design of the documentation, as well as the design considerations taken into account during the creation of the experiment. Chapter III describes the experimental tasks, characteristics, organization, methodology, and experimental group. Chapter IV analyses the results. Chapter V summarizes the accomplishments and findings and provides suggestions for further research.

II. PREPARATION OF THE EXPERIMENTAL INTERFACE

A. EXPERIMENTAL DESIGN

The Systems Dynamic Model of Project Management enables the conduct of controlled software management experiments. Depending on the interface used, the model can be used to simulate any or all aspects of a software management project, similar to a flight simulator mimicking any particular type of flight environment. Although the model is capable of simulating any phase of the software development life cycle, in this experiment, the system only mimics the development phase of a software project. That is, the period from the completion of the design phase to the beginning of the testing phase. The player, or subject, plays the role of manager of a software project. Prior to starting the game, the subject is given an instruction sheet that includes a specific goal set.

Two separate project scenarios were constructed to investigate decisions under both relaxed and constrained resource environments. Project A's initial size was underestimated while Project B's size was initially overestimated. For each project, two goal combinations were used for experimental analysis. All combinations contained the element of schedule, for without a schedule constraint, dysfunctional behavior would be invited. Figure 2-1 is a matrix that depicts the goal and project combinations.

	Cost and Schedule		Quality and Schedule	
Project A	A11	A12	A21	A22
Project B	B11	B12	B21	B22

Figure 2-1 Project/Goal Numbering Scheme

1. Cost and Schedule Goal Set

The first goal set is cost and schedule. "Cost and Schedule" was given the number 11. The identical goal set stated in the reverse order as "Schedule and Cost" is given the number 12. For example, goal A11 is stated as "Minimize overruns in <u>both</u> cost and schedule." Goal A12 is stated as "Minimize overruns in <u>both</u> schedule and cost."

Appendix J contains the specific phrasing for the eight project/goal combinations.

2. Quality and Schedule Goal Set

The second combination is Quality and Schedule and is numbered 21. The identical goal set stated in the reverse order as Schedule and Quality is numbered 22. When this number is combined with the specific project the result is a three character alphanumeric that denotes the Project, Goal Set, and the Goal Order. For example, B12 denotes: Project B that decreases in size, Goal 1 of Cost and Schedule, and Order 2 that changes the ordering of the goal set to Schedule and Cost.

3. Experimental Groups

The experimental population had no previous experience with the SDM model. In order to prepare the subjects in running the simulation, each subject received a classroom lecture where the interface was demonstrated. During this period the subjects were told that the experiment was "very real." For example, they understood that hiring delays, turnover, transfers, work force ceilings, and training delays would all affect the actual workforce number. After this training session, each subject performed a practice session named "TOY." Toy was a benign environment that had no specific goal other than to familiarize the subject with the experiment. The project that was managed remained constant in size. The purpose of the training session was to alleviate any unfamiliarity, or discomfort with the gaming interface and to provide a constant level of experience across the experimental group.

4. Independent and Dependent Variables

Each subject made four inputs at each interval throughout the experiment. They were the total workforce requested, the percent of this workforce dedicated to quality assurance activities, the estimated cost to complete the programming phase, and the estimated programming phase duration. The ten project outcome variables shown in Figure 2-2 were captured at the end of the project simulation.

VARIABLE	DESCRIPTION
FNCOST	Final Cost (in Man Days)
FNTIME	Final Cumulative Time (Days)
FNERR	Final Errors Remaining Undetected
FNERG	Final Cumulative Errors Generated
FNERD	Final Cumulative Errors Detected
FNERES	Final Cumulative Errors Excaping Detection
FNPRDT	Final Percentage of Errors Detected
FNQAMD	Final Cumulative Quality Assurance Man Days
FNTRMD	Final Cumulative Training Man Days
FNRWMD	Final Cumulative Rework Man Days

Figure 2-2 Project Outcome Variables

In addition, at each decision point in the simulation (i.e. every 40 days) 27 variables were automatically captured by the software. These variables include the four decisions made by the subject plus the process variables on the specific type of report or graph that was viewed by the subject and the length of time that the information was presented on the screen.

B. SOFTWARE AND DOCUMENTATION

In order to conduct the experiment, there were three distinct efforts in the design of the components. The software interface for the experiment, the instructions for its use, and the questionnaire to be completed at the end of the experiment. The subjects input their decisions into the computer and also wrote them on the documentation sheet to provide a failsafe should there be any computer problems.

The SDM and its associated interface includes many Dynamo executable files as well as Dynex and other programs written in C code. The conduct of the experiment initially requires 28 files on the subject's floppy disk. The files that appear in Figure 2-3 are necessary to start and run the simulation.

FILENAME	SIZE (bytes)	DESCRIPTION
BAT.COM	36,018	EBL Batch file Enhancement Language
CAPTURE. EXE	13,751	Works with TIMESTAMP.EXE
DYNEX.EXE	67,833	Dynamo executable (Executes *.DNX files)
START.BAT	205	Begins the Experiment, copies files to hard disk
INIT.EXE	12,545	C Language file that writes SUBINFO file
INTERVAL.DRS	62	Report that contains currrent interval day
PROJ@.DNX	7,824	Instructions that create interface
PROJ@.RSL	1,099	Results file of all experiment data
PROJ@.STT	2,476	Temporary storage file of user inputs
FINISH.BAT	28	Ends the experiment, copies files back to floppy
DEF.DRS	1,282	Report Specification, Defect Report
DEFPLOT.DRS	168	Report Specification, Defect Graphs
REP.EXE	95,312	Report generation executable, reads *.drs files
SMLT.EXE	101,877	Simulation Executable
STAFFING.DRS	624	Report Specification, Staffing Report
STAFPLOT.DRS	147	Report Specification, Staffing Graphs
STATPLOT.DRS	177	Report Specification, Status Report
STATUS.DRS	1,430	Report Specification, Status Graphs
TIMESTMP.EXE	8,667	Captures number of seconds a report was in view
PERFORM.DRS	166	Writes 10 dependent variables at project end
PROCESS.DRS	550	Writes 27 variables at each decision interval
PROJECT@ BAT	6,600	Overall batch control file
PROCESS.EXE	12,419	Combines subject & process with decision data
PERFORM.EXE	12,079	Combines subject with final performance data
PROJ@.INS	5,798	Dynamo required simulation file
PROJ@.DAT	1,348	Dynamo required simulation file
PROJ@.SMT	7,620	Dynamo required simulation file

Figure 2-3 Initial Experiment Simulation Files

After the simulation is complete there will be 18 additional files created during the run. The additional files appear in Figure 2-4. The files with the extension of .DAT append throughout the experiment. These files must not be on the disk at the beginning or the previous data will contaminate the results.

FILENAME	DESCRIPTION
SUBINFO	The User's name, SMC, Project, Goal, Instruction Set
ERRORS	Created by Dynamo to hold error messages
PROJ@.WAS	The previous PROJ@.CHG
PROJ@.CHG	Holds changes since last PROJ@.OUT
TIME.TMP	Last clock time (used with TIMESTMP.EXE)
CAPTURE.DAT	Historical data of screens viewed *
PROCESS.DAT	Historical data set of variables *
ERRORS.OUT	Historical errors generated by TIMESTMP.EXE
PERFORM.DAT	Final performance data written at project finish *
*.OUT	Copy of all reports generated by REP.EXE (9 total if all are viewed)
	* MUST BE DELETED

Figure 2-4 Files Created During the Experiment

1. Overall Description of System's Architecture

Figure 2-5 is the structure chart of the experiment's software. The main module is PROJECT@.BAT and appears in Appendix A. All of the programs are initially called by the PROJECT@.BAT file. Through the remainder of this thesis, the "@" symbolizes either an A, or B depending on the project in reference. TOY.BAT operates similarly and appears as Appendix B.

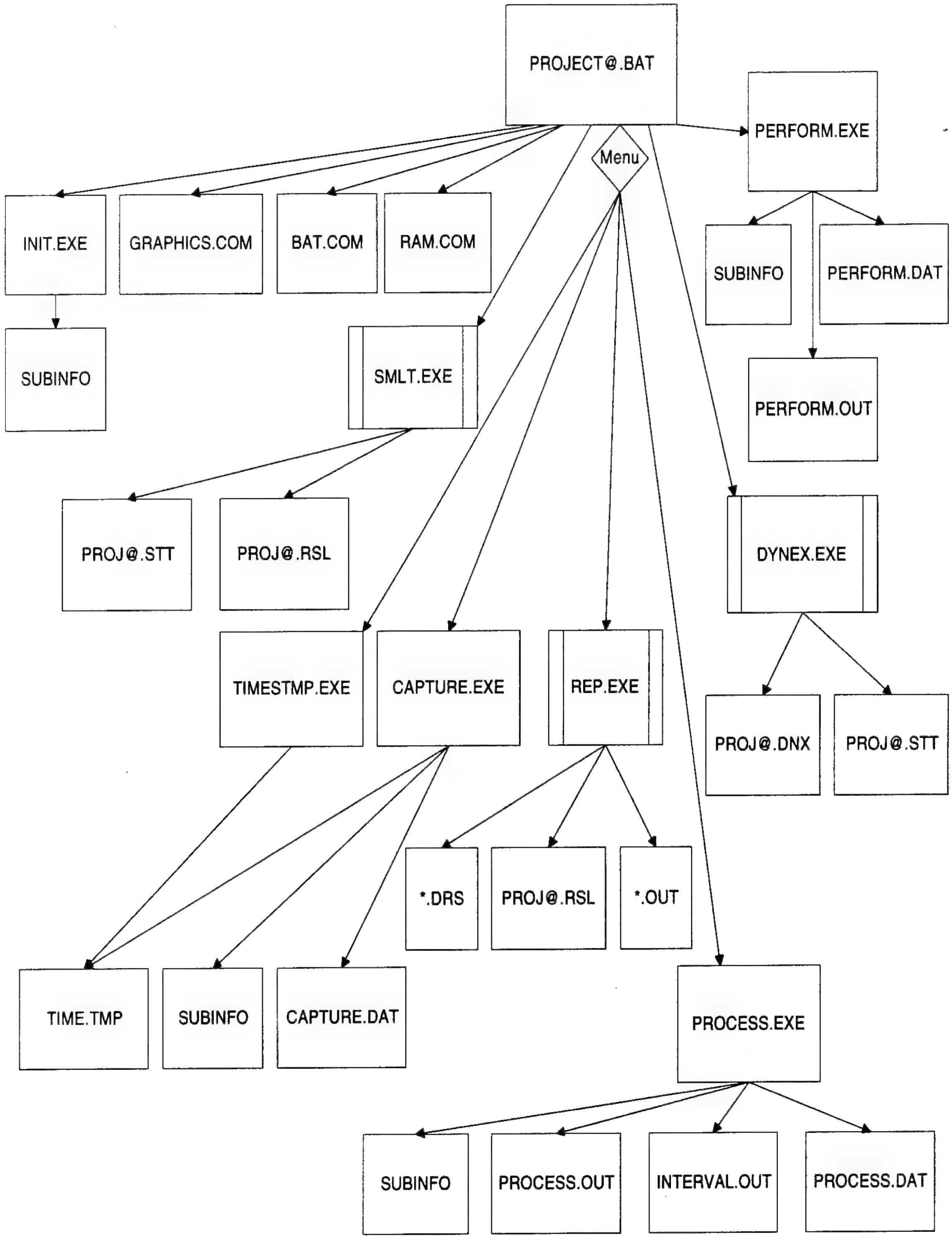


Figure 2-5 Structure Chart of Experiment's Software

a. Experiment Initialization

The experiment starts when the subject types START at the B:\ prompt. At this time START.BAT creates a subdirectory on the subject's computer named C:\SWPROJ. START.BAT then copies the 28 initial files to this directory and calls PROJECT@.BAT (or TOY.BAT for the practice experiment).

PROJECT@.BAT calls INIT.EXE and passes it three parameters; Project, Goal, and Instruction Set. INIT.EXE prompts the subject for their name and Student Mail Center (SMC) number. INIT.EXE then formats and writes this information to the file named SUBINFO. PROJECT@.BAT then calls GRAPHICS.COM. This program is loaded memory resident and is required to display graphical menu information throughout the experiment. Extended Batch Language Plus (BAT.COM) is then loaded to allow a more diverse set of programming constructs than is available through the DOS batch file language. RAM.COM then loads memory resident to speed screen writes throughout the experiment. The preliminary modules necessary to run the repetitive portion (40 day simulation intervals) of the experiment have now been executed.

b. Main Routines

SMLT.EXE is first called to initialize the Dynamo files to day zero. Subsequent calls to SMLT.EXE will happen every 40 days until the project is completed. SMLT.EXE is the Dynamo program that performs the actual simulation calculations. It reads the PROJ@.STT file and writes the results to the file called PROJ@.RSL. The PROJECT@BAT file then prompts the user for their first decisions and then displays the decision menu. The user has six menu selections available that will generate either a report or graph. Selecting one of the first six items will invoke the following sequence of operations: TIMESTMP.EXE will record the current time from the system clock and write this time to TIME.TMP. Next, REP.EXE is called and passed the appropriate *.DRS file depending on the menu item selected. All of the *.DRS files appear as Appendices D, E, F, and G. For example, selecting the Status Report will cause STATUS.DRS to be passed to REP.EXE. The *.DRS file serves as a report format in

which to read the PROJ@.RSL file previously written by SMLT.EXE. The PROJ@.RSL file contains the cumulative results of all variables throughout the entire experiment. The output is both sent to the display and saved as the file named *.OUT. When the subject is finished viewing the report or graph, control is returned to PROJECT@.BAT where CAPTURE.EXE is passed the report or graph identifier. CAPTURE.EXE reads the current time from the system clock and subtracts the time previously recorded in TIME.TMP to calculate the total viewing time that the report was displayed on the screen. This information is joined with the information in SUBINFO and appended to the file named CAPTURE.DAT. The subject can select as many reports or graphs as deemed necessary to assimilate all of the project information. When satisfied, the subject presses "P" to proceed with the next 40 day interval.

Upon pressing "P" PROCESS.EXE is called to perform data manipulation and recording. PROCESS.EXE combines the subject's information from SUBINFO with the period that was recorded in INTERVAL.OUT. This information is merged with the current data residing in PROCESS.OUT and appended to the file PROCESS.DAT.

To complete the main routines, DYNEX.EXE is called and passed the appropriate PROJ@.DNX file. PROJ@.DNX appears as Appendix C and contains the prompting for the four independent variables WFS2, FRMPQ1, JBSZMD, FRMPQ1. Appendix O contains the full description of the variables. DYNEX.EXE, by executing the PROJ@.DNX commands, displays the current value of the variables and allows the subject to change and verify the new value. When satisfied, the user presses <ENTER>, PROJ@.STT is written, and the user is returned to the PROJECT@.BAT main menu. This sequence is repeated until the subject reaches project completion.

c. Experiment Finalization

The subjects were instructed to call the lab attendant when the project was complete. To finish the experiment and capture all of the recorded data the lab attendant pressed the <CONTROL> and <Q> keys simultaneously. This first invokes one last call to REP.EXE with PERFORM.DRS being passed. The resulting file is PERFORM.OUT.

PERFORM.EXE is then invoked and joins the contents of SUBINFO with PREFORM.OUT. The result is written to the file PERFORM.DAT. Finally, FINISH.BAT is called to copy the entire contents of C:\SWPROJ back to the B:\ drive where the disk was removed from the computer and retained by the lab attendant.

2. Files Critical to Experiment Operation

Appendix H contains the source code for all of the routines necessary to capture the experimental data. File names with the .C extension are written in the C language. START.BAT and FINISH.BAT are not shown in the structure chart but were previously discussed.

3. Documentation

The documentation was considered critical to the experiment's success. The documentation for the experiment was in three parts. The first portion was termed the "Instruction Set" and contained the instructions that were specific to each experimental group. Each subject also received a copy of the "Description of the Simulation Interface." This document contained general instructions to operate the interface, i.e. view reports and graphs, and was distributed to each subject in their envelope at the beginning of both the Toy and Actual experiments. These two documents and the accompanying disk were placed in a large manilla envelope for each subject. The third part was the Project Questionnaire. The questionnaire was completed by each subject at the end of the actual experiment.

4. Instruction Set

The instruction set distributed to the subjects with project/goal/order A11 appears as Appendix I. Each combination was created from the Master Instruction Set that appears as Appendix J. The text contained between brackets in Appendix J contains instructions to the experiment designer on how to properly cut and paste the appropriate verbiage for each project/goal/order set. There were a total of nine different sets of instructions created. One for the practice experiment, and one for each of the eight project/goal/order combinations.

5. Description of the Simulation Interface

The Description of the Simulation Interface appears as Appendix K. This document's intent was to help the subjects familiarize themselves with the user interface. The handout included an example of all of the reports and graphs available to the user between project intervals. A short description of the information was also included. This information was distributed prior to both the practice and actual experiments. All participants received the same information. A second (identical to the first) copy was distributed to participants for the actual experiment. This was to prevent any note taking or recording of formulas that might skew the experiment results.

6. Project Questionnaire

Two versions of the Project Questionnaire were developed. The composite version appears as Appendix K. Each questionnaire had either a X1X or X2X in the upper right hand corner. X1X denotes that Question 1 would ask for the percentages concerning cost and schedule. X2X asked for percentages concerning quality and schedule. All other questions were identical. The questionnaires were not included in the envelope that each subject received prior to conducting the experiment, but were retained by the lab attendants and distributed to the subjects at project completion. The questionnaires served to both gather demographic data on the subjects, and collect feedback concerning the conduct and performance of the experiment.

C. TEST EXPERIMENT

In order to validate the user interface, pilot experiments were conducted with seven subjects. The pilots were conducted at three separate sittings, allowing time to incorporate their suggestions between the sessions. Numerous incremental improvements were implemented concerning clarity and organization of the report and graph screens. Particular attention was paid to the scaling of the graphs. Every attempt was made to not "lead" the subject's decisions by a too constrictive or too exaggerated scale being placed on a graph. A thorough scrubbing of the instructions was also accomplished concerning ease of understanding and organization.

D. FINAL PREPARATIONS

Having completed the interface design, documentation, and follow-up questionnaire, seven copies of each of the eight project disks were made. 25 copies of the follow-up questionnaire were made for both goal set 1 and 2. Individual envelopes were prepared for each participant and their name written on the outside. Signs were prepared and posted on the doors to both labs the evening before to prevent nonparticipants from entering the lab during the conduct of the experiment.

III. CONDUCT OF THE EXPERIMENT

A. TASKS AND PROJECT CHARACTERISTICS

Having completed the PRACTICE experiment, all of the participants were given an additional opportunity to ask questions prior to the actual experiment. Some questions were answered concerning whether there was any incentive to finish ahead of schedule. In response to these questions, the participants were told the project that they were managing was a portion of a larger project. Finishing their portion early would put them "out of sync" with the larger project and result in dead time for their staff. This left no questions that there was no reward for gross over staffing or other dysfunctional behavior in order to finish early.

The participants were reminded that they were to work alone and not to discuss anything with anyone other than the lab attendant. All participants were told that their performance on the experiment would be incorporated into their class participation portion of the grade for IS-4300.

B. ORGANIZATION OF THE EXPERIMENT

The introduction to the actual experiment consisted of a 15 minute training session in which each participant was given their personal envelope and informed of its contents. The experimental guidelines were reviewed for the last time. A seating chart was distributed to each subject and appears as Appendix N. All of the computers were checked prior to the experiment and making the seating assignments. None of the students with similar goals were seated next to each other. As noted in the appendix, several machines had mechanical problems and were not used. An opportunity was provided to settle any last minute questions before the participants were directed to the lab.

The size of the experimental group required that two separate sessions, each session split in half and distributed across two labs simultaneously. A lab assistant was present in each lab to ensure compliance with the seating chart and to provide general

guidance throughout the experiment. Lab assistants had special copies of the seating chart that also indicated the project/goal of each participant. This was done in the event that any subject's computer might malfunction creating the need for reassignment. Although not necessary in the actual assignment, with this information the lab assistant could ensure that no subjects with the same project/goal would be seated next to each other when reassigned. Both lab assistants also maintained the copies of the project questionnaire to be distributed to the subjects at the completion of the experiment. The experiment designer served as the lab assistant in one lab and made periodic checks with the other lab attendant to ensure that all of the subject's concerns were being handled uniformly between the labs. The same persons served as lab attendants in both the morning and afternoon sessions. Both experimental groups were started at the same time. No information was given to the subjects on how to calculate staffing levels or how to interpret the reports. Both lab assistants had readily at hand, spare disks for each of the eight project configurations, and had back-up copies of all of the documentation. The entire experiment was conducted within one day. All subjects were completed with the experiment within two hours.

C. THE EXPERIMENTAL SUBJECTS

The subjects in this experiment were students from two sections of the Software Engineering and Management course, IS-4300, taught at the Naval Postgraduate School. Section one consisted of 25 students, section two had 24 students. The groups were randomized and assigned to each of the eight project/goal sets in the following manner.

1. Random Number Assignment

Students in the two sections were listed sequentially in the order that they appeared on the registration roster as shown is the first portion of Appendix M. The first column is the sequential list of the 49 students. A standard list of random numbers was chosen (Daniel, 1975). The last three digits were used. Random numbers were assigned sequentially to each subject in the second column of the Appendix.

2. Project Assignment

The subjects were then sorted by their random number and appear as the second portion of Appendix M. Now that the subjects were in a random order, each was assigned a project in sequence. The projects were assigned in the order of A11, A12, A21, A22, B11, B12, B21, B22. Robinson, whose number was the highest at 978 was initially not assigned a project. Without Robinson, each group was balanced with 6 subjects each. Robinson was to be assigned to any project in the event of one of the other subjects was not present on the day of the actual experiment. All of the subjects were present however, and Robinson was assigned the next project in sequence, A11.

D. DEPENDENT MEASURES

Ten performance variables were captured at the completion of the experiment. Of these, three are the most indicative of project performance and will be used as the dependent variables. The first of these is Final Cost, FNCOST. (See appendix O for the key to deciphering variable names). FNCOST is the cost in person days expended to complete the project.

The second dependent variable is the Final Time. FNTIME is the day that the project was completed. All subjects had the goal of completing the project within the estimated time and were reminded that there was no incentive to finish early.

The third, and last dependent variable is FNERR. FNERR is the value indicating the number of cumulative errors remaining in the software at project completion. This value indicated the quality of the software, i.e. fewer errors indicating higher quality software.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

A. MODEL OF ANALYSIS

For each subject, the raw data produced by this experiment was written to three files. The data concerning the final results of the experiment was captured to the file named PERFORM.DAT. Data was also captured at each decision interval (40 days) and written to the file called PROCESS.DAT. Between each interval, when the subjects were viewing reports and graphs, data was captured on the length of time and type of information that was being viewed. This data was written to the file named CAPTURE.DAT. The three data sets appear as Appendices P, Q, and R respectively.

Analysis of this data was conducted using Statistical Analysis System (SAS) software. Specifically, three procedures within the software were used. Procedure MEANS, was used to determine the means and significance. Procedure General Linear Model (GLM) was used for multi variate analyses due to the unequal populations within project groups. Procedure Correlation (CORR) was used to detect any correlation between independent and dependent variables. The SAS program files appear as Appendix S.

B. PROJECT A

Data was recorded on each participant throughout the project. At project completion, ten final performance variables were recorded in the file named PERFORM.OUT. A full description of the variable names appears in Appendix O. The file format appears in Appendix H. Analysis was performed on these ten variables to determine if there were significant differences between the two project groups.

1. Performance Data

The analysis of each subject's performance focused on three dependent variables, namely FNCOST, FNSKED, and FNERR. Project A1 subject's goals are cost and schedule. Project A2's goals are quality and schedule. Figure 4-1 depicts the means and the standard deviations for the performance variables in project A.

a. Schedule

The time taken to complete the project was recorded in the variable named FNSKED. There was no statistical difference between groups with respect to FNSKED. The null hypothesis cannot be rejected ($F(1,23)=1.28$; $P< 0.2688$). This is not surprising as both groups had schedule as a goal.

b. Cost

The final cost of the project was recorded in the variable named FNCOST. The units of FNCOST are person-days. Within project A, only group 1 had the goal of minimizing cost. The average cost to complete the project for goal 1 was significantly lower than goal 2. Thus the null hypothesis is rejected with respect to FNCOST ($F(1,23)=16.39$; $P< 0.0005$).

c. Quality

The final errors remaining in the project at completion were recorded in the variable named FNERR. Within project A, only goal 2 contained quality. The average number of final errors was significantly lower in group A2, thereby rejecting the null hypothesis with respect to FNERR ($F(1,23)=12.81$; $P<0.0016$).

	FNSKED {in Days} Mean (Std. Dev)	FNCOST {in Person Days} Mean (Std. Dev)	FNERR {# Errors} Mean (Std. Dev)
Goal 1- Cost and Schedule	297 (45)	1500 (165)	1591 (805)
Goal 2 - Quality and Schedule	319 (55)	1963 (375)	742 (166)

Figure 4-1 Means and Standard Deviations for Project A

The results show that goals do matter. Each group performed significantly better in their unique goal. The performance of both groups showed no statistical difference with respect to the common goal, schedule.

2. Process Data

The subjects were required to make four decisions at each 40 day interval. The first decision was to select the total staffing level. This value was captured in the variable WFS2. The second decision was to allocate a percent of this staff to quality assurance activities. This value was captured in the variable FRMPQ1. The two additional decisions are estimates of the project's final cost and completion time. These decisions were captured in the variables JBSZMD and SCHCDT respectively. Appendix N contains the key to deciphering the variable names. All decision variables were written to the file named PROCESS.DAT.

The actual completion time of the project was dependent on the particular decisions made by the manager. In graphing the group means of the process data, the last interval shown for Project A is 240 days. This is the last interval in which all of the subjects had not completed the project and were still making decisions.

Three types of analyses were conducted on the means of the process data. The first was to determine if there is a period effect, i.e. the values changed over time. Next, the data was analyzed to determine if there was interaction between the groups with different goals. Lastly, analysis was conducted to determine if there was significant difference between subjects.

a. Total Staff

Figure 4-2 is a graph of the group means for total staff requested by subjects managing Project A. The analysis of the means as shown in the graph indicates that there is a period effect. The null hypothesis for no period effect is rejected with respect to WFS2 ($F(6,18)=3.26$; $P<0.0239$). The null hypothesis for interaction however, cannot be rejected due to the large standard deviation ($F(6,18)=0.72$; $P<0.3704$). The test for difference between groups indicates that the null hypothesis cannot be rejected, indicating that there is no significant difference between subjects with different goals ($F(1,23)=2.84$; $P<0.1057$).

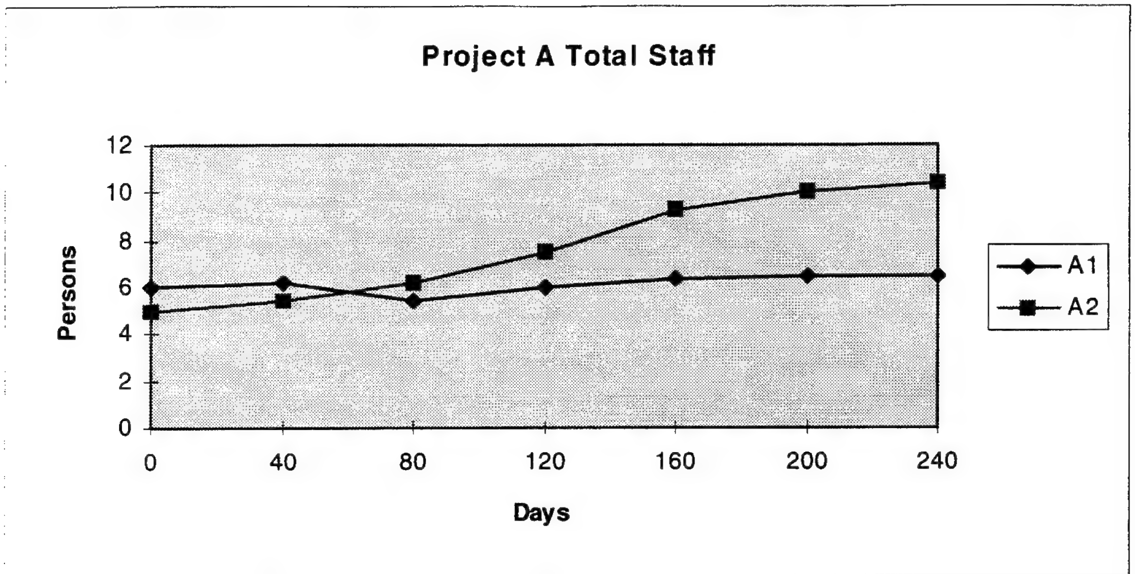


Figure 4-2 Total Staff Requested for Project A.

b. Quality Assurance

Figure 4-3 is a graph of the percent of the total workforce allocated to quality assurance activities. The graph indicates that there is no period effect with respect to FRMPQ1. The null hypothesis cannot be rejected ($F(6,18)=1.8459$; $P<0.1464$). The test for interaction between groups over time also fails to reject the null hypothesis that there is interaction between goal groups ($F(6,18)=1.0016$; $P<0.4543$). Between subjects analysis does not reject the null hypothesis indicating that there is not significant difference between goals ($F(1,23)=1.002$; $P<0.4543$).

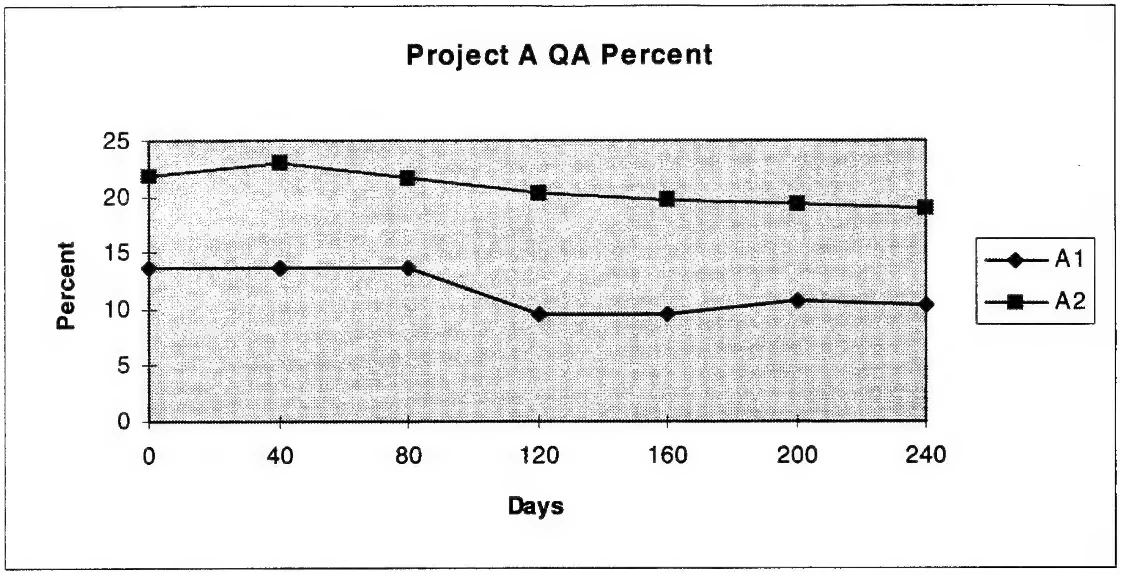


Figure 4-3 Percent of Requested Staff Allocated to QA for Project A

c. Cost Estimates

Figure 4-4 depicts the estimate for total project cost at for the subjects that managed Project A. The graph shows a strong time effect for the subject's cost estimate, rejecting the null hypothesis with respect to JBSZMD ($F(6,18)=9.27$; $P<0.0001$). There is no interaction between groups ($F(6,18)=.0652$; $P<0.7229$). The between subjects analysis indicates that there is not a significant difference between goals over time. Therefore, there is no significance between groups with respect to JBSZMD ($F(1,23)=2.65$; $P<0.1174$).

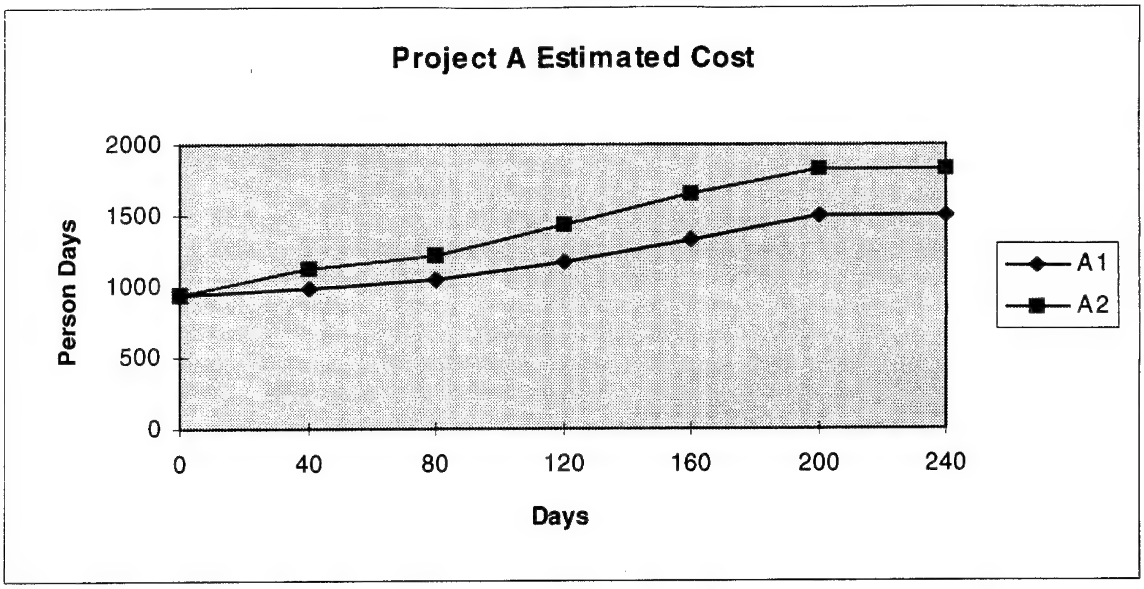


Figure 4-4 Estimated Completion Cost for Project A

d. Schedule Estimates

Figure 4-5 illustrates the subject's estimated project schedule as the project progressed. Analysis for period effect shows that the null hypothesis of no period effect can be rejected with respect to SCHCDT ($F(6,18)=3.0713$; $P<0.0300$). There is no significant interaction between groups ($F(6,18)=1.8736$; $P<0.1410$). The null hypothesis for no between subjects effects also cannot be rejected ($F(1,23)=2.18$; $P<0.1530$).

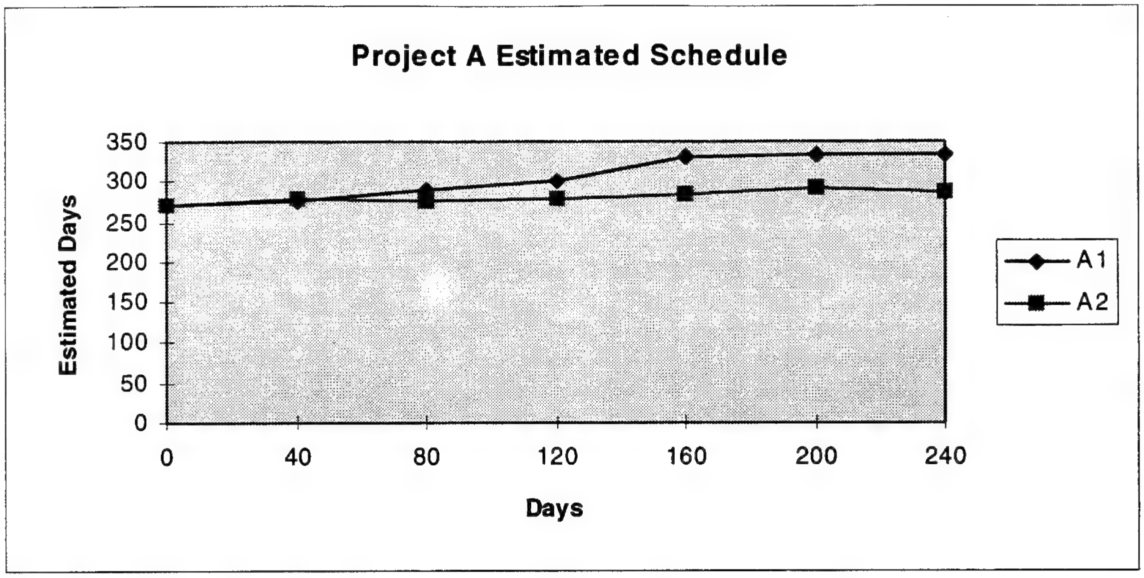


Figure 4-5 Estimated Schedule for Project A

C. PROJECT B

1. Performance Data

Project B1 subject's goals are cost and schedule. Project B2's goals are quality and schedule. The time required to complete the project was recorded in the variable named FNSKED. Figure 4-6 indicates an abnormally high standard deviation for FNSKED. This was due to subject number 26 as indicated in Appendix P. Subject 26 allotted zero staff to quality assurance activities in order to obtain the absolute minimum cost. This subject is more than three standard deviations from the mean with respect to FNERR. Figure 4-6 depicts the means and the standard deviations for the final determinate variables in project B when subject 26 is included in the data set.

	FNSKED {in Days} Mean (Std. Dev)	FNCOST {in Person Days} Mean (Std. Dev)	FNERR {# Errors} Mean (Std. Dev)
Goal 1- Cost and Schedule	247 (28)	1702 (212)	2080 (2422)
Goal 2 - Quality and Schedule	254 (28)	1983 (237)	1006 (481)

Figure 4-6 Means and Standard Deviations for Project B with Subject 26

Figure 4-7 depicts the means and the standard deviations for the final determinate variables in project B when subject 26 is removed from the data set.

	FNSKED {in Days} Mean (Std. Dev)	FNCOST {in Person Days} Mean (Std. Dev)	FNERR {# Errors} Mean (Std. Dev)
Goal 1- Cost and Schedule	245 (28)	1751 (133)	1396 (540)
Goal 2 - Quality and Schedule	257 (28)	1983 (237)	1006 (481)

Figure 4-7 Means and Standard Deviations for Project B deleting Subject 26

a. Schedule

The SAS programs were rerun with subject 26 removed from the data set. This analysis of FNSKED shows that there is no statistical difference between groups. The null hypothesis is not rejected. ($F(1,21)=.78$; $P< 0.4079$)

b. Cost

The final cost of the project was recorded in the variable named FNCOST. The units of FNCOST are person-days. Again, only subjects with goal 1 were to minimize cost. The average cost to complete the project was significantly lower, thereby rejecting the null hypothesis ($F(1,21)=8.15$; $P< 0.0095$).

c. Quality

The final errors remaining in the project at completion were recorded in the variable named FNERR. Group B2 had the goal of producing quality software. Although the average number of final errors was lower, there is a weak significance. The null hypothesis could not be safely rejected as in the previous project ($F(1,21)=3.36$; $P<0.0810$).

2. Process Data

The requested total staffing levels for Project B including subject 26 are depicted in figure 4-8. The results were the same with subject 26 removed from the data set. The subjects with goal 2 maintained higher workforce levels throughout the project.

a. Total Staff

The graph indicates that there is a period effect with respect to WFS2. The null hypothesis is rejected ($F(5,18)=4.8165$; $P<0.0057$). The test for interaction between groups over time does not reject the null hypothesis indicating there is no interaction between goal groups ($F(5,18)=1.576$; $P<0.2171$). Between subjects analysis rejects the null hypothesis indicating that there is a significant difference between goals ($F(1,22)=4.22$; $P<0.0520$).

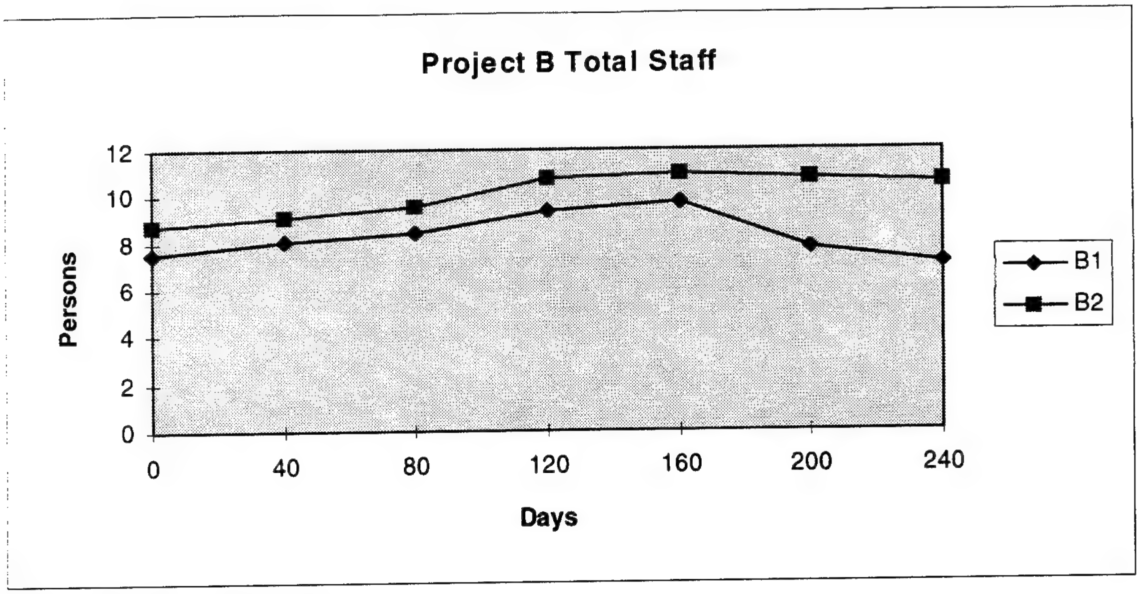


Figure 4-8 Total Staff Requested for Project B

b. Quality Assurance

Figure 4-9 depicts the percent of the requested workforce allocated to quality assurance activities for project B. The graph indicates that there is also a period effect with respect to FRMPQ1. The null hypothesis is rejected ($F(5,18)=3.9476$; $P<0.0136$). The test for interaction does not reject the null hypothesis indicating no interaction between goal groups ($F(5,18)=0.9534$; $P<0.4714$). Between subjects analysis rejects the null hypothesis indicating that there is significant difference between goals ($F(1,22)=9.52$; $P<0.0054$).

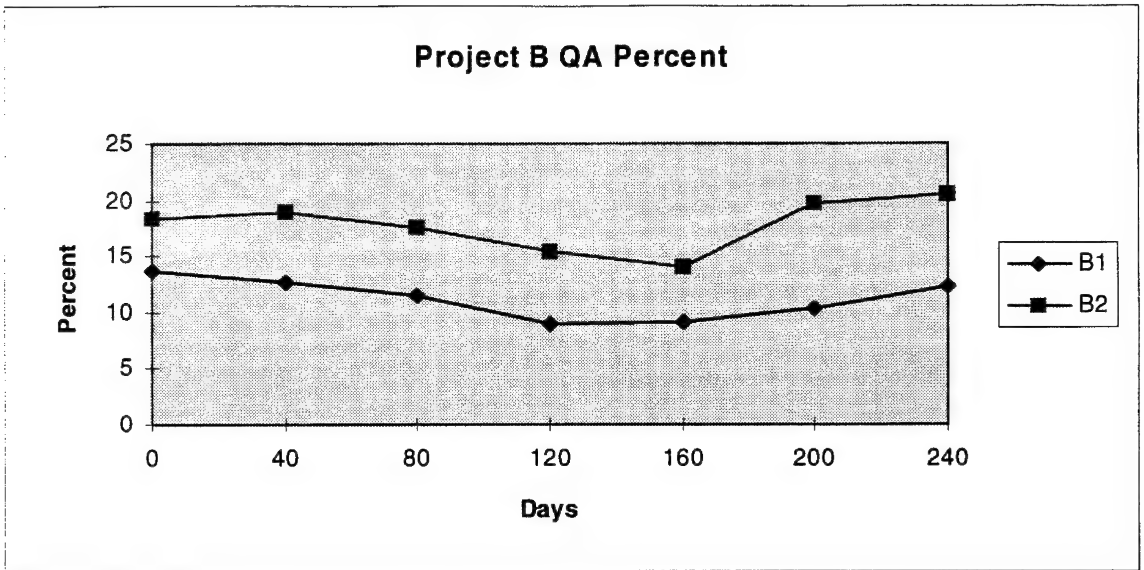


Figure 4-9 Percent of Requested Staff Allocated to QA for Project B

c. Cost Estimates

Figure 4-10 depicts the estimate for total project cost at completion for the subjects that managed Project B. There is no indication of period effect with respect to JBSZMD. The null hypothesis is not rejected ($F(5,18)=1.3381$; $P<0.2932$). The test for interaction does not reject the null hypothesis indicating no significant interaction between goal groups ($F(5,18)=1.5331$; $P<0.2292$). Between subjects analysis indicates that there is a slight significant difference between goals ($F(1,22)=3.02$; $P<0.0947$).

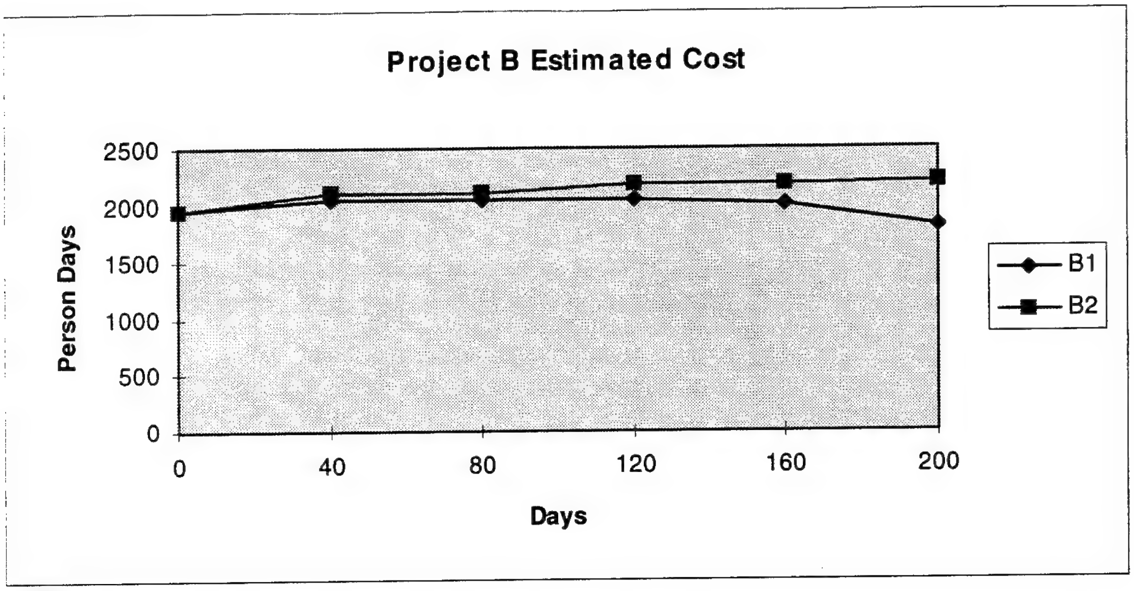


Figure 4-10 Estimated Completion Cost for Project B

d. Schedule Estimates

Figure 4-11 illustrates the subject's estimated project schedule as the project progressed. Analysis for period effect shows that the null hypothesis of no period effect is not rejected with respect to SCHCDT ($F(5,18)=1.5829$; $P<0.2152$). There is no significant interaction between groups ($F(6,18)=0.8939$; $P<0.5059$). Between subjects effects do not reject the null hypothesis indicating no significant difference between groups ($F(1,22)=0.68$; $P<0.4188$).

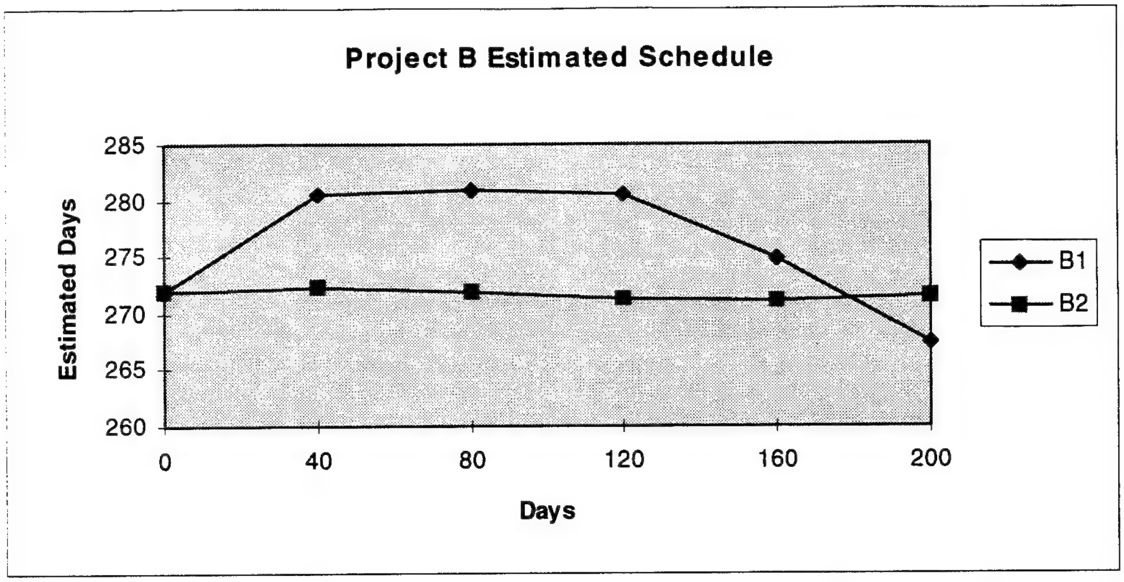


Figure 4-11 Estimated Schedule for Project B

D. QUESTIONNAIRE AND DEMOGRAPHIC DATA

1. Sample Profile

The population exhibited some interesting demographics. The mean age of the subjects was 33.7 years. On average, the subjects had 12 years of work experience and had completed their undergraduate education 10.3 years ago. Not surprisingly, the subjects spend about 15.3 hours per week using a computer. The mean grade for the IS-4300 course was 3.45 grade points.

2. Correlations with the Results

SAS correlations were run to determine if any sample demographics were correlated with the experiment results. None of the population demographics were significantly correlated. In particular, the course grade for IS-4300 showed no significance for any of the project groups. Slight correlations were found between some of the determinate variables and the population demographics.

a. Project A1

Figure 4-12 indicates the correlations and (significance) for Project A goal 1 for the variables age, computer hours per week, work experience, years ago

undergraduate education completed, and grade in the IS-4300 course. A slight significance in the correlation between EDAGO and FNSKED can be seen.

	AGE	CHRSWK	WKEXP	EDAGO	GRADE
FNERR	-0.3426 (0.2518)	-0.2572 (0.3963)	-0.3812 (0.1988)	-0.2977 (0.3232)	-0.1421 (0.6434)
FNSKED	0.4229 (0.1499)	-0.2304 (0.4488)	0.2930 (0.3313)	0.5033 (0.0795)	0.0273 (0.9294)
FNCOST	0.4556 (0.1177)	-0.0410 (0.8943)	0.3586 (0.2289)	0.4322 (0.1402)	0.1250 (0.6841)

Figure 4-12 Project A Goal 1 Demographic Correlations and (Significance) Levels

b. Project A2

Figure 4-13 indicates a correlation between AGE and FNCOST. No other correlations exist for Project A2.

	AGE	CHRSWK	WKEXP	EDAGO	GRADE
FNERR	-0.1958 (0.5419)	0.1756 (0.5851)	-0.0527 (0.8709)	-0.1001 (0.7569)	0.0853 (0.7921)
FNSKED	-0.3148 (0.3189)	-0.0394 (0.9032)	-0.2851 (0.3690)	-0.2677 (0.4002)	-0.1085 (0.7373)
FNCOST	0.6716 (0.0168)	-0.1223 (0.7048)	-0.0527 (0.8709)	0.4005 (0.1970)	0.0613 (0.8499)

Figure 4-13 Project A Goal 2 Demographic Correlations and Significance Levels

c. Project B1

Figure 4-14 shows that there are no correlations between demographics and performance for Project B1.

	AGE	CHRSWK	WKEXP	EDAGO	GRADE
FNERR	-0.0353 (0.9133)	0.3834 (0.2186)	-0.0489 (0.8799)	0.0093 (0.9770)	0.1164 (0.7186)
FNSKED	0.0567 (0.8611)	-0.0971 (0.7641)	0.0044 (0.9892)	0.0877 (0.7863)	0.4083 (0.1876)
FNCOST	0.9133 (0.7777)	-0.0647 (0.8146)	0.0789 (0.8074)	0.00835 (0.7963)	0.0011 (0.9972)

Figure 4-14 Project B Goal 1 Demographic Correlations and Significance Levels

d. Project B2

Figure 4-15 depicts a slight correlation between WKEXP and FNCOST. No other correlations are noted for this project.

	AGE	CHRSWK	WKEXP	EDAGO	GRADE
FNERR	0.3929 (0.2064)	-0.2906 (0.3596)	0.3444 (0.2730)	0.5360 (0.0725)	-0.1003 (0.7566)
FNSKED	-0.4271 (0.1661)	0.1847 (0.5655)	-0.4504 (0.1417)	-0.2912 (0.3585)	-0.1574 (0.6252)
FNCOST	0.5947 (0.8543)	0.2537 (0.4264)	-0.1619 (0.0849)	-01916 (0.5508)	0.1915 (0.5510)

Figure 4-15 Project B Goal 2 Demographic Correlations and Significance Levels

V. CONCLUSIONS

A. FINDINGS AND IMPLICATIONS

The objective of this thesis was to conduct a controlled experiment focused on gaining insight into the affect of stated goals on software project management. This thesis provides empirical findings regarding the software project managers's behavior in both relaxed and constrained resource environments.

The experimental results confirm that goals do matter. Managers perform best in the goals that they are given. This research also confirms that the affect of goals on programmers in the Weinberg experiment can be extended to software project managers. Additionally, it confirms that different software objectives, i.e. quality, cost, and schedule are indeed in conflict with each other.

B. FURTHER RESEARCH

There are several areas that can be potentially researched using the Systems Dynamic Model of Software Project Management. This experiment could be replicated with different subjects. One particular area would be to conduct the experiment with professional software manages to see if they respond similarly to stated goals. Project outcome may differ when managed by professional managers.

Another area to be researched concerns goal commitment. In this thesis goals were given to the manager. No attempt was made to analyze the level of commitment to these goals. Further research could be conducted to measure both the initial commitment to the goals and whether this commitment was maintained over time. The effects of goal commitment on project performance could be analyzed.

Lastly, interaction between feedback and goal commitment could be researched. Investigation into whether outcome feedback or process feedback has the greater effect on goal commitment.

APPENDIX A. PROJECT@.BAT

```
@echo off
rem PROJ@ is the initially underestimated project
rem Ver 10  13 Nov 94
cls
rem init.exe requires 3 parameters i.e. [project,group,ins.set]
init @ # #
graphics
bat /n /p /s
ram
smlt PROJ@ -go = -prs = -ls -ns -plm 16
rep PROJ@.RSL PROCESS.DRS -outf PROCESS.OUT -t >NUL
rep PROJ@.RSL PROCESS.DRS -outf PROCESSS.OUT -t >NUL

-top    dynex PROJ@ -in PROJ@.STT -sc -ls -plm 16
      smlt PROJ@ -gm = -ns -plm 16
      copy process.out process.old >NUL
      rep PROJ@.RSL PROCESS.DRS -outf PROCESS.OUT -t >NUL
      rep PROJ@.RSL PROCESS.DRS -outf PROCESSS.OUT >NUL
      rep PROJ@.RSL INTERVAL.DRS -outf INTERVAL.OUT -t >NUL
      process

      call -top1
      rep PROJ@.RSL PERFORM.DRS -outf PERFORM.OUT -t >NUL
      perform
      rem finish
      exit

-top1   cls

-menu
      color \1F
      cls
      begtype
```

```
                         REPORTS AND GRAPHS MENU

\1EREPORTS: \1F
            \1E 1     \1F PROJECT STATUS \1EREPORT\1F

            \1E 2     \1F STAFFING \1EREPORT\1F

            \1E 3     \1F DEFECT \1EREPORT\1F


\1BGRAPHS:\1F
            \1B 4     \1F PROJECT STATUS \1BGRAPH\1F

            \1B 5     \1F STAFFING \1BGRAPH\1F

            \1B 6     \1F DEFECT \1BGRAPH\1F

PRESS  \1D P   \1F TO \1DPROCEED\1F TO ENTER DECISIONS FOR THE NEXT 40 DAYS
Choose an option: (Do NOT hit <ENTER> after selection!!!)    ;
end

-1stkey1 inkey %2 | type %2;
      if %2 = 1 goto -STATREP
      if %2 = 2 goto -STAFREP
      if %2 = 3 goto -DEFREP
      if %2 = 4 goto -STATPLOT
      if %2 = 5 goto -STAFPLOT
      if %2 = 6 goto -DEFPLOT
      if %2 = P goto -proceed
      if %2 = KEY011 return
      beep goto -menu


-STATREP **** VIEW PROJECT STATUS REPORT ********************
      timestmp
      rep PROJ@ STATUS.DRS -outf STATUS.OUT -t -sc -ls -plm 16
      inkey
      capture R1 >NUL
      cls
      color \1F
      goto -menu


-STAFREP  **** VIEW STAFFING REPORT ********************
      timestmp
      rep PROJ@ STAFFING.DRS -outf STAFFING.OUT -t -sc -ls -plm 16
      inkey
      capture R2 >NUL
      cls
      color \1F
      goto -menu
```

```
-DEFREP  **** VIEW DEFECT REPORT *******************
      timestmp
      rep PROJ@ DEF.DRS -outf DEF.OUT -t -sc -ls -plm 16
      inkey
      capture R3 >NUL
      cls
      color \1F
      goto -menu

-STATPLOT **** VIEW PROJECT STATUS PLOT ****
      timestmp
      cls
      color \1F
      begtype



********************************************************************************
   \1A                    PROJECT STATUS VARIABLES                      \1F
********************************************************************************

         THE FOLLOWING PROJECT STATUS VARIABLES WILL BE PLOTTED:


  TOTAL STAFF. . . . . . . . TOTAL STAFF LEVEL
  EST SYSTEM SIZE. . . . . . CURRENT ESTIMATE OF SYSTEM SIZE (KDSI)
  EST PROGRAMMING COST . . . CURRENT ESTIMATE OF PROGRAMMING COST (Person Days)



  \1A     AFTER VIEWING PLOT PRESS <ESC> TO RETURN TO THE MENU  \1F



  \1A     PRESS <ENTER> TO VIEW PLOT   \1F

end
      inkey
      cls
      rep PROJ@ STATPLOT.DRS
      capture G4 >NUL
      color \1F
      cls
      goto -menu

-STAFPLOT **** VIEW GRAPHIC STAFFING PLOT ****
      timestmp
      cls
      color \1F
      begtype
```

```
*******************************************************************************
   \1A                         STAFFING VARIABLES                          \1F
*******************************************************************************

         THE FOLLOWING STAFFING VARIABLES WILL BE PLOTTED:


    TOTAL STAFF . . . . . . . TOTAL STAFF LEVEL
    QA STAFF. . . . . . . . . NUMBER OF PERSONS ALLOCATED TO QA
    PROG STAFF. . . . . . . . NUMBER OF PERSONS DOING PROGRAMMING



  \1A     AFTER VIEWING PLOT PRESS <ESC> TO CONTINUE  \1F



  \1A     PRESS <ENTER> TO VIEW PLOT   \1F


end
      inkey
      cls
      rep PROJ@ STAFPLOT.DRS
      capture G5 >NUL
      color \1F
      cls
      goto -menu


-DEFPLOT **** VIEW DEFECT PLOT ****
      timestmp
      cls
      color \1F
      begtype



*******************************************************************************
   \1A                          DEFECT VARIABLES                        \1F
*******************************************************************************

        THE FOLLOWING DEFECT VARIABLES WILL BE PLOTTED:


    QA PERSON DAYS PER PERIOD . . . . QA PERSON DAYS EXPENDED PER PERIOD
    DEFECTS DETECTED PER PERIOD . . . DEFECTS DETECTED PER PERIOD



  \1A     AFTER VIEWING PLOT PRESS <ESC> TO RETURN TO THE MENU  \1F
```

```
  \1A     PRESS <ENTER> TO VIEW PLOT    \1F


END
      inkey
      cls
      rep PROJ@ DEFPLOT.DRS
      capture G6 >NUL
      color \1F
      cls
      goto -menu


-proceed  **** PROCEED WITH NEXT SIMULATION ********************
      cls
      color \1F
      begtype



            *************************************************
            *            Press <ENTER> to continue          *
            *************************************************


end
goto -top


-on.error-
 if %R > 82 if %R < 90 type !! Floating Point Error !! |goto -Calc.
 Cls beep type Unexpected batch file error %R in line %L |exit
```

APPENDIX B. PROJ@.DNX

```
if #tm<.1 then
display clear

            **************************************
            !!!! Important Points to Remember !!!!
            **************************************

     - You are not allowed to discuss this exercise with anyone other
       than the lab attendant.  Please refrain from discussing this with
       members in the other class until they have completed the exercise.

     - The system will show you the size of the initial core team of
       software developers who have just completed the requirements/design
       specifications. You will then be asked for your desired staffing level
       for the programming phase. Then, the system will run through the
       first simulation time period (40 working days) and allow you to view
       various reports and graphs.  You will then be allowed to update your
       estimates for project cost and duration and change your staffing levels.

     - Record your decision for each interval on the documentation sheet
       provided before proceeding to the next interval.


       THE LAB ATTENDANT MUST VERIFY YOUR FINAL RESULTS!

     - GOOD LUCK!         Press <ENTER> to continue.
dendq
choice 1
cend 1/1


display clear

   *********************************************************************
   *               INITIAL ESTIMATES FOR THIS PROJECT:                 *
   *          System Size                     15860. DSI               *
   *          Cost of Programming Phase         #TOTMD1  Person Days   *
   *          Duration of Programming Phase     #TDEV  Days            *
   *                                                                   *
   *     The initial core team of software developers who have just    *
   *     completed the requirements and design specifications is       *
   *     #WFS1 people.                                                 *
   *                                                                   *
   *     Your task is to take over as manager of the programming phase.*
   *     At this point, you need to make 2 decisions:                  *
   *                                                                   *
   *     1.  The total staff level for the programming phase.          *
   *                                                                   *
   *     2.  The percent of this staff to allocate to Quality Assurance.*
   *********************************************************************

    -----> FIRST DECISION: The total staff level

     Enter your total requested staff level and press <ENTER>.
dendq
dq WFS1=0.5<
```

```
display clear

     -----> SECOND DECISION:

     NEW_TOOL's estimate for the percent of the total staff to allocate to QA
     is #FRMPQA percent. Remember, NEW_TOOL has not yet been calibrated to your
     environment.  Thus, this estimate is merely illustrative.  It may or may
     not be appropriate for your unique project.

     1) Enter a different desired percentage (a number from 0 - 100)
      and press <ENTER>.

                           OR

     2) Press <ENTER> to allocate #FRMPQA percent of your staff to QA.

dendq
dq FRMPQA=0<100

display clear

Your total requested staffing level =           #WFS1 people.

The percent to be devoted to QA activities =   #FRMPQA percent.
(This means that you are devoting #WFS1 * #FRMPQA / 100  = #WFS1*FRMPQA/100 people
to QA)

         ********************************************************
         *                  !!  IMPORTANT  !!                   *
         *                                                      *
         *     This is your final opportunity to check and      *
         *     change the values for this period.               *
         *                                                      *
         *     Press 1 then <ENTER> to change these values.     *
         *                                                      *
         *     If all values are correct, record them on        *
         *     the documentation sheet provided then            *
         *                                                      *
         *     Press 2 then <ENTER> to continue.                *
         *                                                      *
         ********************************************************

dend
choice 2

display
Your total requested staffing level =
dendq
dq WFS1=0.5<

display
The percent allocated to QA =
dendq
dq FRMPQA=0<100

cend
cend
```

```
else


choice 1
cend 1/1
display clear
          **************************************************
          *   Make Your Desired Changes To The Variables   *
          *              and press <ENTER>                 *
          *                    OR                          *
          *    Press <ENTER> to keep the displayed value   *
          **************************************************

Your updated estimate for project cost (person days) =
dendq
dq TOTMD1=0<

display
Your updated estimate for project duration (days) =
dendq
dq PROJDR=0<

display
Your total requested staffing level =
dendq
dq WFS1=0.5<

display
The percent to allocate to QA (a number from 0 - 100) =
dendq
dq FRMPQA=0<100


display clear

Your updated estimate for project cost =           #TOTMD1  person days
Your updated estimate for project duration =       #PROJDR days
Your total requested staffing level =                #WFS1 people
The percent to be devoted to QA activities =        #FRMPQA percent
(This means that you are devoting #WFS1 * #FRMPQA / 100  = #WFS1*FRMPQA/100 people
to QA)

        ********************************************************
        *                  !!  IMPORTANT  !!                   *
        *                                                      *
        *      This is your final opportunity to check and     *
        *      change the values for this period.              *
        *                                                      *
        *      Press 1 then <ENTER> to change these values.    *
        *                                                      *
        *      If all values are correct, record them on       *
        *      the documentation sheet provided then           *
        *                                                      *
        *      Press 2 then <ENTER> to continue.               *
        *                                                      *
        ********************************************************

dend
```

```
choice 2

display
The updated estimate for project cost (person days) =
dendq
dq TOTMD1=0<

display
The updated estimate for project duration (days) =
dendq
dq PROJDR=0<

display
Your total requested staffing level =
dendq
dq WFS1=0.5<

display
The percent allocated to QA =
dendq
dq FRMPQA=0<100

cend
cend


end
display
     ***********************************************************************
     *                                                                     *
     *   Press <ENTER> to simulate this interval and return to the menu.  *
     *                                                                     *
     ***********************************************************************
dendq
choice 1
display clear
```

```
              ********************************************
              *                                          *
              *                                          *
              *    There will be a short pause while     *
              *    the model simulates the next period.  *
              *                                          *
              *                                          *
              ********************************************
```

```
dendq
report
time=maxtime,
cend 1/1

spec md_length=#length+40
```

APPENDIX C. TOY. BAT

```
@echo off
rem TOY is the practice project
rem Ver 10  13 Nov 94
cls
rem init.exe requires 3 parameters i.e. [project,group,ins.set]
init T 1 1
graphics
bat /n /p /s
ram
smlt TOY -go = -prs = -ls -ns -plm 16
rep TOY.RSL PROCESS.DRS -outf PROCESS.OUT -t >NUL
rep TOY.RSL PROCESS.DRS -outf PROCESSS.OUT -t >NUL

-top    dynex TOY -in TOY.STT -sc -ls -plm 16
      smlt TOY -gm = -ns -plm 16
      copy process.out process.old >NUL
      rep TOY.RSL PROCESS.DRS -outf PROCESS.OUT -t >NUL
      rep TOY.RSL PROCESS.DRS -outf PROCESSS.OUT >NUL
      rep TOY.RSL INTERVAL.DRS -outf INTERVAL.OUT -t >NUL
      process

      call -top1
      rep TOY.RSL PERFORM.DRS -outf PERFORM.OUT -t >NUL
      perform
      finish
      exit

-top1   cls

-menu
      color \1F
      cls
      begtype
```

```
                         REPORTS AND GRAPHS MENU

 \1EREPORTS: \1F
             \1E 1    \1F PROJECT STATUS \1EREPORT\1F

             \1E 2    \1F STAFFING \1EREPORT\1F

             \1E 3    \1F DEFECT \1EREPORT\1F
```

```
\1BGRAPHS:\1F
            \1B 4    \1F PROJECT STATUS \1BGRAPH\1F

            \1B 5    \1F STAFFING \1BGRAPH\1F

            \1B 6    \1F DEFECT \1BGRAPH\1F

PRESS  \1D P   \1F TO \1DPROCEED\1F TO ENTER DECISIONS FOR THE NEXT 40 DAYS

Choose an option: (Do NOT hit <ENTER> after selection!!!)    ;
end

-1stkey1 inkey %2 | type %2;
      if %2 = 1 goto -STATREP
      if %2 = 2 goto -STAFREP
      if %2 = 3 goto -DEFREP
      if %2 = 4 goto -STATPLOT
      if %2 = 5 goto -STAFPLOT
      if %2 = 6 goto -DEFPLOT
      if %2 = P goto -proceed
      if %2 = KEY011 return
      beep goto -menu


-STATREP **** VIEW PROJECT STATUS REPORT ********************
      timestmp
      rep TOY STATUS.DRS -outf STATUS.OUT -t -sc -ls -plm 16
      inkey
      capture R1 >NUL
      cls
      color \1F
      goto -menu


-STAFREP  **** VIEW STAFFING REPORT ********************
      timestmp
      rep TOY STAFFING.DRS -outf STAFFING.OUT -t -sc -ls -plm 16
      inkey
      capture R2 >NUL
      cls
      color \1F
      goto -menu


-DEFREP  **** VIEW DEFECT REPORT ********************
      timestmp
      rep TOY DEF.DRS -outf DEF.OUT -t -sc -ls -plm 16
      inkey
      capture R3 >NUL
      cls
      color \1F
      goto -menu
```

```
-STATPLOT **** VIEW PROJECT STATUS PLOT ****
      timestmp
      cls
      color \1F
      begtype



*******************************************************************************
   \1A                        PROJECT STATUS VARIABLES                      \1F
*******************************************************************************

         THE FOLLOWING PROJECT STATUS VARIABLES WILL BE PLOTTED:


  TOTAL STAFF. . . . . . . . TOTAL STAFF LEVEL
  EST SYSTEM SIZE. . . . . . CURRENT ESTIMATE OF SYSTEM SIZE (KDSI)
  EST PROGRAMMING COST . . . CURRENT ESTIMATE OF PROGRAMMING COST (Person Days)



  \1A      AFTER VIEWING PLOT PRESS <ESC> TO RETURN TO THE MENU  \1F



  \1A      PRESS <ENTER> TO VIEW PLOT   \1F


end
      inkey
      cls
      rep TOY STATPLOT.DRS
      capture G4 >NUL
      color \1F
      cls
      goto -menu

-STAFPLOT **** VIEW GRAPHIC STAFFING PLOT ****
      timestmp
      cls
      color \1F
      begtype



*******************************************************************************
   \1A                             STAFFING VARIABLES                     \1F
*******************************************************************************

         THE FOLLOWING STAFFING VARIABLES WILL BE PLOTTED:
```

```
    TOTAL STAFF . . . . . . . . TOTAL STAFF LEVEL
    QA STAFF. . . . . . . . . . NUMBER OF PERSONS ALLOCATED TO QA
    PROG STAFF. . . . . . . . . NUMBER OF PERSONS DOING PROGRAMMING



  \1A     AFTER VIEWING PLOT PRESS <ESC> TO CONTINUE  \1F



  \1A     PRESS <ENTER> TO VIEW PLOT   \1F

end
      inkey
      cls
      rep TOY STAFPLOT.DRS
      capture G5 >NUL
      color \1F
      cls
      goto -menu


-DEFPLOT **** VIEW DEFECT PLOT ****
      timestmp
      cls
      color \1F
      begtype



********************************************************************************
   \1A                         DEFECT VARIABLES                        \1F
********************************************************************************

       THE FOLLOWING DEFECT VARIABLES WILL BE PLOTTED:


    QA PERSON DAYS PER PERIOD . . . . QA PERSON DAYS EXPENDED PER PERIOD
    DEFECTS DETECTED PER PERIOD . . . DEFECTS DETECTED PER PERIOD



  \1A     AFTER VIEWING PLOT PRESS <ESC> TO RETURN TO THE MENU  \1F



  \1A     PRESS <ENTER> TO VIEW PLOT   \1F

END
      inkey
```

```
        cls
        rep TOY DEFPLOT.DRS
        capture G6 >NUL
        color \1F
        cls
        goto -menu

-proceed   **** PROCEED WITH NEXT SIMULATION *********************
        cls
        color \1F
        begtype


              **************************************************
              *             Press <ENTER> to continue          *
              **************************************************


end
goto -top

-on.error-
 if %R > 82 if %R < 90 type !! Floating Point Error !! |goto -Calc.
 Cls beep type Unexpected batch file error %R in line %L |exit
```

APPENDIX D. STATUS.DRS

```
;
;
report
time=maxtime,
FORMAT="5<"
">>>>>>>>>>>>>>>>>>>>>>> PROJECT STATUS REPORT <<<<<<<<<<<<<<<<<<<<<<<<<";
;
Format="30<,40<,47<",PICTURE="Z,ZZ9V"
"AT TIME =",TM,"DAYS";;
Format="5<"
"INITIAL ESTIMATES: (These will not change throughout the project)";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZZV"
"System Size",IPRJSZ,"DSI";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZZV"
"Programming Cost",TOTMDO,"Person Days";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZZV"
"Programming Phase Duration (start-end)",TDEV,"Days";
;
Format="5<"
"UPDATED ESTIMATES";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V"
"Updated Est of System Size",PJBSZT,"DSI";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V"
"Your Last Est of Programming Phase Cost",JBSZMD,"Person Days";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V"
"Your Last Est of Prog Phase Duration (start-end)",SCHCDT,"Days";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V"
"Time Remaining",TIMERM,"Days";
;
Format="5<"
"REPORTED PROGRESS";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V.99"
"% DSI Reported Complete",PRCMPL,"Percent";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V"
"Total DSI Reported Complete to Date",CMDSI,"DSI";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V"
"Total Person Days Expended to Date",CUMMD,"Person Days";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V"
"Reported Productivity",RPPROD,"DSI/Person Day";
;
FORMAT="5<"
"PRESS <ENTER> TO RETURN TO THE MENU"
```

APPENDIX E. STAFFING.DRS

```
;
;
report
time=maxtime,
FORMAT="5<"
">>>>>>>>>>>>>>>>>>>>>>>>>> STAFFING REPORT <<<<<<<<<<<<<<<<<<<<<<<<<<<<";
;
Format="30<,40<,47<",PICTURE="Z,ZZ9V"
"AT TIME =",TM,"DAYS";
;
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZZV.9"
"Current Total Staff Size",FTEQWF,"People";
FORMAT="11<,54<,66<",PICTURE="ZZZ,ZZZV.9"
"Staff Allocated to Programming",CRDVWF,"People";
FORMAT="11<,54<,66<",PICTURE="ZZZ,ZZZV.9"
"Staff Allocated to QA",CRQAWF,"People";;
FORMAT="8<,54<,66<",PICTURE="ZZ,ZZZ9V"
"Percent of Workforce that is Experienced",FRWFEX*100,"Percent";
;
;
;
FORMAT="5<"
"PRESS <ENTER> TO RETURN TO THE MENU";
```

APPENDIX F. DEF.DRS

```
;
;
report
time=maxtime,
FORMAT="5<"
">>>>>>>>>>>>>>>>>>>>>>>> DEFECT REPORT <<<<<<<<<<<<<<<<<<<<<<<<<<<<<";
;
FORMAT="1<,69<,72<",PICTURE="ZZ9V"
"-----CUMULATIVE STATUS FROM START OF PROGRAMMING TO CURRENT DAY
=>",TM,"---------";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZZV"
"TOTAL Person Days Expended to Date",CUMMD,"Person Days";
FORMAT="11<,54<,66<",PICTURE="ZZZ,ZZZV"
"Programming Person Days Expended to Date",CUMMD-CMQAMD,"Person Days";
FORMAT="11<,54<,66<",PICTURE="ZZZ,ZZZV"
"QA Person Days Expended to Date",CMQAMD,"Person Days";
;
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V"
"TOTAL Defects Detected",CMERD,"Defects";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V.99"
"TOTAL KDSI Completed",CMDSI/1000,"KDSI";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V.9"
"Defect Density",CMERD*1000/CMDSI,"Defects/KDSI";
;
FORMAT="1<"
"------------------STATISTICS FOR THE LAST 40 DAY PERIOD ONLY--------------------";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZZV"
"QA Person Days Expended Last 40 Days",PRQAMD,"Days";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V"
"Defects Detected Last 40 Days",PRERD,"Defects";
FORMAT="8<,54<,66<",PICTURE="ZZZ,ZZ9V.9"
"Defect Density Observed Last 40 Days",PRDFDS,"Defects/KDSI";
;
;
FORMAT="5<"
"PRESS <ENTER> TO RETURN TO THE MENU";
```

APPENDIX G. *PLOT.DRS FILES

STATPLOT.DRS:

```
plotxy <TM"TIME (DAYS) ",0,480>,<FTEQWF"TOTAL STAFF (PERSONS) ",0,16>,
 <PJBSZT/1000"EST SYSTEM SIZE (KDSI) ",0,40>,
 <JBSZMD"EST PROGRAMMING COST (PERSON DAYS) ",0,4000>
```

STAFPLOT.DRS:

```
plotxy <TM"TIME (DAYS) ",0,480>,<FTEQWF"TOTAL STAFF (PERSONS) ",0,24>,
 <CRQAWF"QA STAFF (PERSONS) ",0,24>,<CRDVWF"PROG STAFF (PERSONS) ",0,24>
```

DEFPLOT.DRS:

```
plotxy <TM"TIME (DAYS) ",0,480>,<PRQAMD"QA PERSON DAYS PER PERIOD ",0,160>,
 <PRERD"DEFECTS DETECTED PER PERIOD ",0,160>
```

APPENDIX H. DATA CAPTURING FILES

START.BAT:

```
cls
@echo off
@echo.
@echo.
@echo               Starting the Project Simulation.
@echo.
@echo  Copying files...
@echo.
mkdir c:\swproj
copy *.* c:\swproj
c:
cd c:\swproj
cls
projecta
```

INIT.C:

```
/* INIT.C - Put init info in file  */

#include      "stdio.h"
#include      "dos.h"
#include      "ctype.h"
#include      "se.h"

#define       OUTFILE "subinfo"

main(argc, argv)
int argc;
char *argv[];
{
        char   name[30], smc[10];
        FILE   *fo, *fopen();

if(argc<3)
        {
          printf("\nPlease enter arguments in the following order:");
          printf("\n  Project, objectives, order");
          exit(0);
        }
```

```
    /* Get init info from screen */
        cls();
        set_cursor(6,5);
        printf("Please enter Your Last Name");
        set_cursor(6,35);
        scanf("%s", name);
        set_cursor(7,5);
        printf("Please enter your smc");
        set_cursor(7,35);
        scanf("%s", smc);
        if((fo=fopen(OUTFILE, "w"))==NULL) {
                printf("\couldn't open %s for write", OUTFILE);
                exit(0);
                }

        fprintf(fo, "\n%s %s %s %s %s",name,smc,argv[1],argv[2],argv[3]);
        fclose(fo);
}
```

TIMESTMP.C:

```
/* INFOCFB.C - Read infile containing data and put it in outfile.
        Reads 14 lines and prints out 12 values.*/

#include    "stdio.h"
#include    "dos.h"
#include    "ctype.h"
#include    "se.h"

#define TIMESTAMP     "time.tmp"

main(argc, argv)
int argc;
char *argv[];
{
        FILE   *fo, *fopen();
        struct info userinfo;
        /*
        printf("\nEntered timestmp");
        getch();
        */
        _dos_gettime(&userinfo.start_time);
        if((fo=fopen(TIMESTAMP, "w"))==NULL) {
                printf("\couldn't open %s for write", TIMESTAMP);
                exit(0);
```

```
                }

        fprintf(fo,"%#2d:%#2d:%#2d ", userinfo.start_time.hour,\
                userinfo.start_time.minute,\
                userinfo.start_time.second);
  /* printf("\nTime stamped\n"); */
   fclose(fo);
}
```

INTERVAL.DRS:

```
REPORT
TIME=MAXTIME,
FORMAT="5<",PICTURE="ZZZ,ZZ9V";
TM
```

CAPTURE.C:

```
/* Capture.C - Read infile containing data and put it in outfile.
  For the goals experiment */

#include      "stdio.h"
#include      "dos.h"
#include      "ctype.h"
#include      "se.h"

#define       INFILE   "intrval.out"
/*
#define       OUTFILE "info"
*/
#define       TIMESTAMP  "time.tmp"
#define       TMP        "tmp.tmp"
#define       ERRFILE    "errors.out"

main(argc, argv)
int argc;
char *argv[];
{
        char   outfile[15], tmp[30], estimate[10];
        float  input;
        double period;
        FILE   *fi, *fo, *ftmp, *ferr,  *fopen();
        int    i,hr[3],min[3],sec[3],ch,starttime[6],endtime[6],time;
        struct info userinfo;
```

```
    struct find_t  c_file;
/*
printf("\nEntered capture");
getch();
*/
    /*open errors file */

    if((ferr=fopen(ERRFILE, "a"))==NULL) {
            printf("\couldn't open %s for append", ERRFILE);
            exit(0);
            }

/*Get  previous time and read it into array */
    if(_dos_findfirst(TIMESTAMP, _A_NORMAL, &c_file)==0)
     /* printf("time file found\n"); */ ;
    else
      fprintf(ferr, "\nCouldnt find %s", TIMESTAMP);
    if((fi=fopen(TIMESTAMP, "r"))==NULL) {
            fprintf(ferr, "\ncouldn't open %s for read", TIMESTAMP);
            }
    for(i=0; i<2; i++) {
                    ch = fgetc(fi);
                    if(isdigit(ch))
                            hr[i]=(ch - toascii(48));
                    else
                            hr[i] = 0;
                    }
    ch=fgetc(fi);
    for(i=0; i<2; i++) {
                    ch = fgetc(fi);
                    if(isdigit(ch))
                            min[i]=(ch - toascii(48));
                    else
                            min[i] = 0;
                    }

    ch=fgetc(fi);
    for(i=0; i<2; i++) {
                    ch = fgetc(fi);
                    if(isdigit(ch))
                            sec[i]=(ch - toascii(48));
                    else
                            sec[i] = 0;
                    }
    fclose(fi);
```

```
/*Fill up the start_time array */
for(i=0; i<2; i++)
        starttime[i]=hr[i];
for(i=0; i<2; i++)
        starttime[i+2]=min[i];
for(i=0; i<2; i++)
        starttime[i+4]=sec[i];
/*
for(i=0; i<6; i++)
        printf("%d", starttime[i]);
*/
strcpy(outfile, "");
strcat(outfile, OUTFILE);
strcat(outfile, argv[1]);
if((fi=fopen(INFILE, "r"))==NULL) {
        fprintf(ferr,"\ncouldn't open %s for read", INFILE);
        }
if((fo=fopen(outfile, "a"))==NULL) {
        fprintf(ferr,"\ncouldn't open %s for append", outfile);
        }

fscanf (fi, "%s", estimate);
fscanf (fi, "%f", &input);
period = input;
/* printf("Input and period are %f  %f\n", input, period);
fprintf (fo, "%f  ", period); */
if(period==0) {
        fprintf(fo, "%#3.1f ", period);
        for (i=0; i<15; i++) {
          fscanf(fi, "%s ", tmp);
          fprintf(fo, "%s ", tmp);
          }
    }
else {
    fprintf(fo, "%s  ", estimate);
    fprintf(fo, "\n");
    fprintf(fo, "%#2f ", period);
    for(i=0; i<15; i++) {
          fscanf(fi, "%s ", tmp);
          fprintf(fo, "%s ", tmp);
          }
    }
fclose(fi);

/*get  end_time and print to file */
```

```
_dos_gettime(&userinfo.end_time);
 if((ftmp=fopen(TMP, "w"))==NULL) {
        fprintf(ferr,"\ncouldn't open %s for write", TMP);
        exit(0);
        }
 fprintf(ftmp,"%#2d:%#2d:%#2d ", userinfo.end_time.hour,\
         userinfo.end_time.minute, userinfo.end_time.second);
 fclose(ftmp);

/*Read back end_time into array */
for(i=0; i<2; i++) {
    hr[i]=0;
    min[i]=0;
    sec[i]=0;
    }
if((fi=fopen(TMP, "r"))==NULL) {
        fprintf(ferr,"\ncouldn't open %s for read", TMP);
        }

    for(i=0; i<2; i++) {
                ch = fgetc(fi);
                if(isdigit(ch))
                        hr[i]=(ch - toascii(48));
                else
                        hr[i] = 0;
                }
    ch=fgetc(fi);
    for(i=0; i<2; i++) {
                ch = fgetc(fi);
                if(isdigit(ch))
                        min[i]=(ch - toascii(48));
                else
                        min[i] = 0;
                }

    ch=fgetc(fi);
    for(i=0; i<2; i++) {
                ch = fgetc(fi);
                if(isdigit(ch))
                        sec[i]=(ch - toascii(48));
                else
                        sec[i] = 0;
                }
    fclose(fi);
```

```
        /*Fill up the end_time array */
        for(i=0; i<2; i++)
                endtime[i]=hr[i];
        for(i=0; i<2; i++)
                endtime[i+2]=min[i];
        for(i=0; i<2; i++)
                endtime[i+4]=sec[i];
        /*
        printf("\n");
        for(i=0; i<6; i++)
                printf("%d", endtime[i]);
        */
        /*Get time diff and write to  outfile */
        time = get_time(starttime, endtime);

        fprintf(fo, "  %#3d ", time);
        fclose(fo);
        fclose(ferr);
        remove("tmp.tmp");
        remove("time.tmp");

}


get_time(start_time, end_time)
        int     start_time[], end_time[];
{
        int     start_sec, end_sec, tot_time;

        start_sec=(start_time[0]*10+start_time[1])*3600\
                  +(start_time[2]*10+start_time[3])*60\
                  +(start_time[4]*10+start_time[5]);

        end_sec=(end_time[0]*10+end_time[1])*3600\
                  +(end_time[2]*10+end_time[3])*60\
                  +(end_time[4]*10+end_time[5]);

        tot_time=end_sec-start_sec;
        return(tot_time);
}
```

PROCESS.DRS:

```
REPORT
TIME=MAXTIME,
FORMAT="5<",PICTURE="ZZZZZ9V.99";;
TM
Format="5<,15<,25<,35<,45<,55<,65<",PICTURE="ZZZZZ9V.99";
IPRJSZ,TOTMDO,TDEV,PJBSZT,FNERR,FNERG,TIMERM
Format="5<,15<,25<,35<,45<,55<,65<",PICTURE="ZZZZZ9V.99";
PRCMPL,CMDSI,CUMMD,RPPROD,FTEQWF,CRDVWF,CRQAWF
Format="5<,15<,25<,35<,45<,55<,65<",PICTURE="ZZZZZ9V.99";
FRWFEX*100,CMQAMD,CMERD,PRQAMD,PRERD,PRDFDS,PRTKDV
Format="5<,15<,25<,35<,45<",PICTURE="ZZZZZ9V.99";
TOTMD1,WFS,CRRWWF,AFMDPJ,SCHPR
Format="5<,15<,25<,35<",PICTURE="ZZZZZ9V.99";
WFS2,FRMPQ1,JBSZMD,SCHCDT
```

PROCESS.C:

```
/* process.c  - Read infile containing data and put it in outfile.
  For the goals experiment */

#include      "stdio.h"
#include      "dos.h"
#include      "ctype.h"
#include      "se.h"

#define       INFOFILE  "subinfo"
#define       INFILE1   "process.old"
#define       INFILE2   "process.out"

#define       OUTFILE "process.dat"

#define       ERRFILE    "errors.out"

main()
{
        char   outfile[15], tmp[30], estimate[15];
        char   lname[30], smc[15], project[5], objectives[5], order[5];
        char   duration[30], cost[30], staff[30], percent[30];
        int    i;
        float  input;
        FILE   *finfo, *fi1, *fi2,  *fo,  *ferr,  *fopen();
        struct find_t  c_file;
```

```
/*open errors file */

if((ferr=fopen(ERRFILE, "a"))==NULL) {
        printf("\couldn't open %s for append", ERRFILE);
        exit(0);
        }
/*Open infofile */
if((finfo=fopen(INFOFILE,"r"))==NULL) {
        fprintf(ferr, "\ncouldn't open %s for read", INFOFILE);
        exit(0);
        }
    fscanf(finfo, "%s", lname);
    fscanf(finfo, "%s", smc);
    fscanf(finfo, "%s", project);
    fscanf(finfo, "%s", objectives);
    fscanf(finfo, "%s", order);

    fclose(finfo);


    if((fi1=fopen(INFILE1, "r"))==NULL) {
        fprintf(ferr,"\ncouldn't open %s for read",INFILE1);
        exit(0);
        }
if((fi2=fopen(INFILE2, "r"))==NULL) {
        fprintf(ferr, "\ncouldnt open %s for read", INFILE2);
        exit(0);
        }

    if((fo=fopen(OUTFILE, "a"))==NULL) {
        fprintf(ferr, "\ncouldnt open %s for append", OUTFILE);
        exit(0);
        }
fprintf(fo,"\n%s %s %s %s %s ",lname,smc,project,objectives,order);
for(i=0; i<27; i++) {
    fscanf(fi1, "%s", estimate);
    fprintf(fo, "%s ", estimate);
```

PERFORM.DRS:

```
REPORT
TIME=MAXTIME,
Format="5<,15<,25<,35<,45<,55<,65<,75<,85<,95<",PICTURE="ZZZZZ9V.99";
FNCOST,FNTIME,FNERR,FNERG,FNERD,FNERES,FNPRDT,FNQAMD,FNTRMD,FNRWMD
```

PERFORM.C

```
/* perform.c  - Read infile containing performance date and put
   it in outfile perform.dat. For the goals experiment */

#include      "stdio.h"
#include      "dos.h"
#include      "ctype.h"
#include      "se.h"

#define       INFOFILE  "subinfo"
#define       INFILE1   "perform.out"

#define       OUTFILE "perform.dat"

#define       ERRFILE    "errors.out"

main()
{
        char   outfile[15], tmp[30], estimate[15];
        char   lname[30], smc[15], project[5], objectives[5], order[5];
        int    i;
        FILE   *finfo, *fi,  *fo,  *ferr,  *fopen();

        /*open errors file */
        if((ferr=fopen(ERRFILE, "a"))==NULL) {
                printf("\couldn't open %s for append", ERRFILE);
                exit(0);
                }
    /*Open infofile */
    if((finfo=fopen(INFOFILE,"r"))==NULL) {
                fprintf(ferr, "\ncouldn't open %s for read", INFOFILE);
                exit(0);
                }
        fscanf(finfo, "%s", lname);
        fscanf(finfo, "%s", smc);
        fscanf(finfo, "%s", project);
        fscanf(finfo, "%s", objectives);
        fscanf(finfo, "%s", order);

        fclose(finfo);


        if((fi=fopen(INFILE1, "r"))==NULL) {
                fprintf(ferr,"\ncouldn't open %s for read",INFILE1);
```

```
                exit(0);
                }

        if((fo=fopen(OUTFILE, "w"))==NULL) {
                fprintf(ferr, "\ncouldnt open %s for write", OUTFILE);
                exit(0);
                }
    fprintf(fo,"\n%s %s %s %s %s ",lname,smc,project,objectives,order);
    for(i=0; i<10; i++) {
            fscanf(fi, "%s", estimate);
            fprintf(fo, "%s ", estimate);
            }
    fclose(fi);
    fclose(ferr);
    fclose(fo);

    }

            }
    for(i=0; i<10; i++)
            fscanf(fi2, "%s", tmp);

    fscanf(fi2, "%s", duration);
    fprintf(fo, "%s ", duration);
    fscanf(fi2, "%s", cost);
    fprintf(fo, "%s ", cost);
    fscanf(fi2, "%s", staff);
    fprintf(fo, "%s ", staff);
    fscanf(fi2, "%s", percent);
    fprintf(fo, "%s ", percent);

    fclose(fi1);
    fclose(fi2);
    fclose(ferr);
    fclose(fo);

    }
```

FINISH.BAT:

```
echo off
cls
copy *.* b:
```

APPENDIX I. A11 INSTRUCTION SET

Your Name: ______________________________ A11
SMC No.: ______________________________

1. Introduction

The exercise you are about to undertake is similar in many ways to flight simulators that pilots use to mimic flying an aircraft from takeoff at point A to landing at point B. Instead of flying an aircraft, though, the simulator mimics the programming phase of a real software project. In this simulation, you will be more than an observer. In fact, you will play the role of manager of the programming phase of the project. Specifically, your role will be to track the progress of the project by reviewing status reports and graphs available every two-month interval (40 working days) during the programming phase. As the manager, you must then make two staffing decisions. First, the total number of staff you need. (You can hire additional staff, or decrease the staffing level as you deem necessary to complete your programming task successfully.) Second, you need to decide on what percent of your total staff to allocate to the Quality Assurance activity to be conducted throughout the programming phase (e.g. to do inspections).

2. Project

The project that you will manage happens to have been a real project conducted in a real organization. For the project, you will be given a project profile containing the following initial information:

Estimated Size of the System:	in Delivered Source Instructions (DSI)
Estimated Cost of Programming Phase:	in Number of Person Days
Estimated Duration of Programming Phase:	in Number of Work Days
Size of initial Core Team:	in People

The Core Team is a skeleton staff of software professionals who are there to ensure continuity between the requirements/design phase (which you may assume has just been completed), and the programming phase you are to manage.

The cost and schedule estimates are derived from a new off-the-shelf estimation tool, call it "NEW_TOOL", that has been recently acquired.

Historically, the defect density (i.e. number of defects detected during programming divided by the number of KDSI developed) has ranged from 5 - 20 Defects/KDSI.

3. Your task

Your task at every 40-day interval is to review the project's status, and make any necessary adjustments to the staffing level and its allocation. In order to do so, you may feel that is necessary to first adjust the project's cost and duration targets. The staffing decision should be done as follows:

1. Decide on the total staffing level, and

2. Decide on what percentage of the staff should be allocated to the quality assurance function (i.e. a number between 0 and 100).

4. Your Goal for the Task:

Minimize overruns in both cost and schedule

Your grade for the simulation will be based on an equal weighing of these two factors.

5. Some Important Points to Consider in Managing Your Task

1. As the manager of the programming phase, you specify the desired staffing level. You may find that your actual staffing level (as it will appear in the reports) is different from what you requested. This would be due to factors you cannot control, such as hiring delays and turnover.
2. The staff size that you select, and which appears in reports, may show fractions (e.g. 4.5 people) since people are allowed to work on more than one project.

3. When requesting additional staff, expect a delay in hiring. For modest additions to your staffing, the average hiring delay will be around 40 days. However, if you request a large number of additional staff, the average hiring delay will be much longer.

4. Once new people are hired, they must be trained and assimilated. The assimilation/training period is typically 80 days. During this assimilation/training period you can expect the new employee to be only half as productive as an experienced employee.

5. Adding more people increases communication and coordination overhead as happens in reality.

6. Rules of the Game

1. You must work alone. At no time are you to discuss the progress of the project with anyone.

2. If you have a question, ask the lab attendant.

3 You are not allowed to bring any notes or other "gouge" to use during the simulation. Feel free to write on the documentation sheets provided.

4. A calculator is allowed and recommended.

7. Instructions for Starting the System

<u>Follow the instructions Carefully</u>. If any problems arise, **immediately** seek out the lab attendant.

1. Insert the disk into the B: drive. Do not remove the disk from the drive!

2. From the C:\ prompt, type B: Do NOT start the network!

3. Start the simulation by typing START at the B:\ prompt.

4. Follow the instructions as they appear on the screen.

5. The simulation is complete when the **% Programming Reported Complete** in the PROJECT STATUS REPORT is 100%. When this occurs **<u>Call the lab attendant.</u>**

Your Name: ______________________________
SMC No.: ______________________________

YOUR GOAL IS:

Minimize overruns in both cost and schedule

INITIAL ESTIMATES:

Project Size	15,860 DSI
Project Cost	944 Person Days
Project Duration (start-end)	272 Days

TIME ELAPSED (DAYS)	ESTIMATED COST (PERS-DAYS)	ESTIMATED DURATION (DAYS)	STAFFING LEVEL (PERSONS)	QUALITY ASSURANCE (PERCENT)
Initial Decision	944	272		
Time Elapsed - 40 Days				
Time Elapsed - 80 Days				
Time Elapsed - 120 Days				
Time Elapsed - 160 Days				
Time Elapsed - 200 Days				
Time Elapsed - 240 Days				
Time Elapsed - 280 Days				
Time Elapsed - 320 Days				
Time Elapsed - 360 Days				
Time Elapsed - 400 Days				
Time Elapsed - 440 Days				
Time Elapsed - 480 Days				
Time Elapsed - 520 Days				

****** WHEN YOU ARE DONE, CALL THE LAB ATTENDANT ******

APPENDIX J. MASTER INSTRUCTION SET

Your Name: ______________________________ XXX
SMC No.: ______________________________

1. Introduction

The exercise you are about to undertake is similar in many ways to flight simulators that pilots use to mimic flying an aircraft from takeoff at point A to landing at point B. Instead of flying an aircraft, though, the simulator mimics the programming phase of a real software project. In this simulation, you will be more than an observer. In fact, you will play the role of manager of the programming phase of the project. Specifically, your role will be to track the progress of the project by reviewing status reports and graphs available every two-month interval (40 working days) during the programming phase. As the manager, you must then make two staffing decisions. First, the <u>total</u> number of staff you need. (You can hire additional staff, or decrease the staffing level as you deem necessary to complete your programming task successfully.) Second, you need to decide on what percent of your total staff to allocate to the Quality Assurance activity to be conducted <u>throughout</u> the programming phase (e.g. to do inspections).

2. Project

The project that you will manage happens to have been a real project conducted in a real organization. For the project, you will be given a project profile containing the following initial information:

Estimated Size of the System:	in Delivered Source Instructions (DSI)
Estimated Cost of Programming Phase:	in Number of Person Days
Estimated Duration of Programming Phase:	in Number of Work Days
Size of initial Core Team:	in People

The Core Team is a skeleton staff of software professionals who are there to ensure continuity between the requirements/design phase (which you may assume has just been completed), and the programming phase you are to manage.

The cost and schedule estimates are derived from a new off-the-shelf estimation tool, call it "NEW_TOOL", that has been recently acquired.

Historically, the defect density (i.e. number of defects detected during programming divided by the number of KDSI developed) has ranged from 5 - 20

Defects/KDSI.

3. Your task

Your task at every 40-day interval is to review the project's status, and make any necessary adjustments to the staffing level and its allocation. In order to do so, you may feel that is necessary to first adjust the project's cost and duration targets. The staffing decision should be done as follows:

1. Decide on the total staffing level, and

2. Decide on what percentage of the staff should be allocated to the quality assurance function (i.e. a number between 0 and 100).

4. Your Goal for the Task:

[Paste the appropriate goal from below in this box]

Practice: Familiarize yourself with the simulation

Group A11: Minimize overruns in both cost and schedule.

Group A12: Minimize overruns in both schedule and cost.

Group A21: Deliver a quality product (i.e. detect as many of the defects as possible) and minimize any schedule overrun.

Group A22: Minimize any schedule overrun and deliver a quality product (i.e. detect as many of the defects as possible).

Group B11: Minimize total cost incurred and minimize schedule overrun.

Group B12: Minimize schedule overrun and minimize total cost incurred.

Group B21: Deliver a quality product (i.e. detect as many of the defects as possible) and minimize any schedule overrun.

Group B22: Minimize any schedule overrun and deliver a quality product (i.e. detect as many of the defects as possible).

Your grade for the simulation will be based on an equal weighing of these two factors.

5. Some Important Points to Consider in Managing Your Task

1. As the manager of the programming phase, you specify the desired staffing level. You may find that your actual staffing level (as it will appear in the reports) is different from what you requested. This would be due to factors you cannot control, such as hiring delays and turnover.
2. The staff size that you select, and which appears in reports, may show fractions (e.g. 4.5 people) since people are allowed to work on more than one project.

3. When requesting additional staff, expect a delay in hiring. For modest additions to your staffing, the average hiring delay will be around 40 days. However, if you request a large number of additional staff, the average hiring delay will be much longer.

4. Once new people are hired, they must be trained and assimilated. The assimilation/training period is typically 80 days. During this assimilation/training period you can expect the new employee to be only half as productive as an experienced employee.

5. Adding more people increases communication and coordination overhead as happens in reality.

6. Rules of the Game

1. You must work alone. At no time are you to discuss the progress of the project with anyone.

2. If you have a question, ask the lab attendant.

3 You are not allowed to bring any notes or other "gouge" to use during the simulation. Feel free to write on the documentation sheets provided.

4. A calculator is allowed and recommended.

7. Instructions for Starting the System

Follow the instructions Carefully. If any problems arise, **immediately** seek out the lab attendant.

1. Insert the disk into the B: drive. Do not remove the disk from the drive!

2. From the C:\ prompt, type B: Do NOT start the network!

3. Start the simulation by typing START **[or PRACTICE]** at the B:\ prompt.

4. Follow the instructions as they appear on the screen.

5. The simulation is complete when the **% Programming Reported Complete** in the PROJECT STATUS REPORT is 100%. When this occurs **Call the lab attendant.**

Your Name: ______________________________
SMC No.: ______________________________

YOUR GOAL IS [PASTED FROM EARLIER]

INITIAL ESTIMATES: **[Proj. A, B, Practice--Delete 2]**

Project Size	15,860 DSI
Project Cost	944 Person Days
Project Duration (start-end)	272 Days
Project Size	32,940 DSI
Project Cost	1960 Person Days
Project Duration (start-end)	272 Days
Project Size	20,000 DSI
Project Cost	1,400 Person Days
Project Duration (start-end)	350 Days

TIME ELAPSED (DAYS)	ESTIMATED COST (PERS-DAYS)	ESTIMATED DURATION (DAYS)	STAFFING LEVEL (PERSONS)	QUALITY ASSURANCE (PERCENT)
Initial Decision **[Delete 2>]**	944-1960-1400	272-272-350		
Time Elapsed - 40 Days				
Time Elapsed - 80 Days				
Time Elapsed - 120 Days				
Time Elapsed - 160 Days				
Time Elapsed - 200 Days				
Time Elapsed - 240 Days				
Time Elapsed - 280 Days				
Time Elapsed - 320 Days				
Time Elapsed - 360 Days				
Time Elapsed - 400 Days				
Time Elapsed - 440 Days				
Time Elapsed - 480 Days				
Time Elapsed - 520 Days				

****** WHEN YOU ARE DONE, CALL THE LAB ATTENDANT ******

APPENDIX K. DESCRIPTION OF THE SIMULATION INTERFACE

REPORTS AND GRAPHS MENU:

After every 40-day simulation period, you will immediately get the Reports and Graphs Menu shown below. All of the reports and graphs concerning your project's progress are available from this menu. You may select any of them by pressing their corresponding number.

```
                              REPORTS AND GRAPHS MENU

REPORTS:
              1    PROJECT SIZE & STATUS REPORT

              2    STAFFING REPORT

              3    DEFECT REPORT

GRAPHS:
              4    PROJECT SIZE & STATUS GRAPH

              5    STAFFING GRAPH

              6    DEFECT GRAPH


    PRESS     P    TO PROCEED TO ENTER DECISIONS FOR THE NEXT 40 DAYS
```

After viewing the pertinent information (you may view any report or graph more than once), use the "P" selection to proceed to enter your decisions for the next 40 day simulation period.

Report 1 (PROJECT SIZE & STATUS REPORT) A sample report is pictured below:

```
>>>>>>>>>>>>>>>>>>>>>>>>> PROJECT STATUS REPORT <<<<<<<<<<<<<<<<<<<<<<<<<<<

                        AT TIME =   200  DAYS

INITIAL ESTIMATES:  (These will not change throughout the project)
   System Size                                         20,000    DSI
   Programming Cost                                     1,400    Person Days
   Programming Phase Duration (start-end)                 350    Days

UPDATED ESTIMATES
   New Est of System Size
         due to Changes in Requirements                20,000    DSI
   Your Last Est of Programming Phase Cost              1,567    Person Days
   Your Last Est of Prog Phase Duration (start-end)       353    Days
   Time Remaining                                         153    Days

REPORTED PROGRESS
   % DSI Reported Complete                              63.33    Percent
   Total DSI Reported Complete to Date                 12,665    DSI
   Total Person Days Expended to Date                     817    Person Days
   Reported Productivity                                   16    DSI/Person Day

PRESS <ENTER> TO RETURN TO THE MENU
```

This report contains Project Status information as of a particular day in the programming phase. The report is divided into 3 sections. The top section shows the INITIAL ESTIMATES provided to your customer. This information will not change throughout the project.

The middle portion is the UPDATED ESTIMATES section. The **Updated Est of System Size** can change (increase or decrease) to reflect the addition or deletion of requirements. The entries of **Your Last Est of Programming Phase Cost** and **Your Last Est of Prog Phase Duration (start-end)** would reflect any change in cost and duration that you feel you need to make. The **Time Remaining** is equal to your current estimate of total duration minus current time.

The bottom section is the REPORTED PROGRESS section. Remember that this is "reported" information and is not guaranteed to be totally accurate, especially early in the phase. **Reported Productivity** is simply calculated as **Total DSI Reported Complete to Date** divided by **Total Person Days Expended to Date.**

Your Task is complete when the **% DSI Reported Complete** is 100%.

Report 2 (STAFFING LEVEL REPORT) A sample report is pictured below:

```
>>>>>>>>>>>>>>>>>>>>>>>>>>>> STAFFING REPORT <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

                           AT TIME =    200  DAYS

   Current Total Staff Size                                  4.7    People
      Staff Allocated to Programming                         4.2    People
      Staff Allocated to QA                                   .5    People

   Percent of Workforce that is Experienced                 83      Percent


PRESS <ENTER> TO RETURN TO THE MENU
```

This report contains staffing information as of a particular day in the programming phase. The **Current Total Staff Size** consists of your total staff allocated to both programming activities and QA activities. It is the sum of **Staff Allocated to Programming** and **Staff Allocated to QA.**

The **Percent of Workforce that is Experienced** is also shown on this report. This is the number of experienced people (i.e. already trained/assimilated) divided by the total staff size (which is the sum of experienced and new staff). As mentioned above, once new people are hired, they go through an assimilation/training period. This is the time needed to train a new employee in the mechanics of the project and bring him/her up to speed. A new employee (i.e. one that is being trained) is only half as productive as an experienced employee.

Report 3 (DEFECT REPORT) A sample report is pictured below:

```
>>>>>>>>>>>>>>>>>>>>>>>>>>> DEFECT REPORT <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
---CUMULATIVE STATUS FROM START OF PROGRAMMING TO CURRENT DAY =>  200---------
     TOTAL Person Days Expended to Date                     817     Person Days
        Programming Person Days Expended to Date            735     Person Days
        QA Person Days Expended to Date                      82     Person Days

     TOTAL Defects Detected                                 137     Defects
     TOTAL KDSI Completed                                    12.67  KDSI
     Defect Density                                          10.9   Defects/KDSI
----------------STATISTICS FOR THE LAST 40 DAY PERIOD ONLY--------------------
     QA Person Days Expended Last 40 Days                    18     Person Days
     Defects Detected Last 40 Days                           38     Defects
     Density of defects detected Last 40 Days                11.6   Defects/KDSI

  PRESS <ENTER> TO RETURN TO THE MENU
```

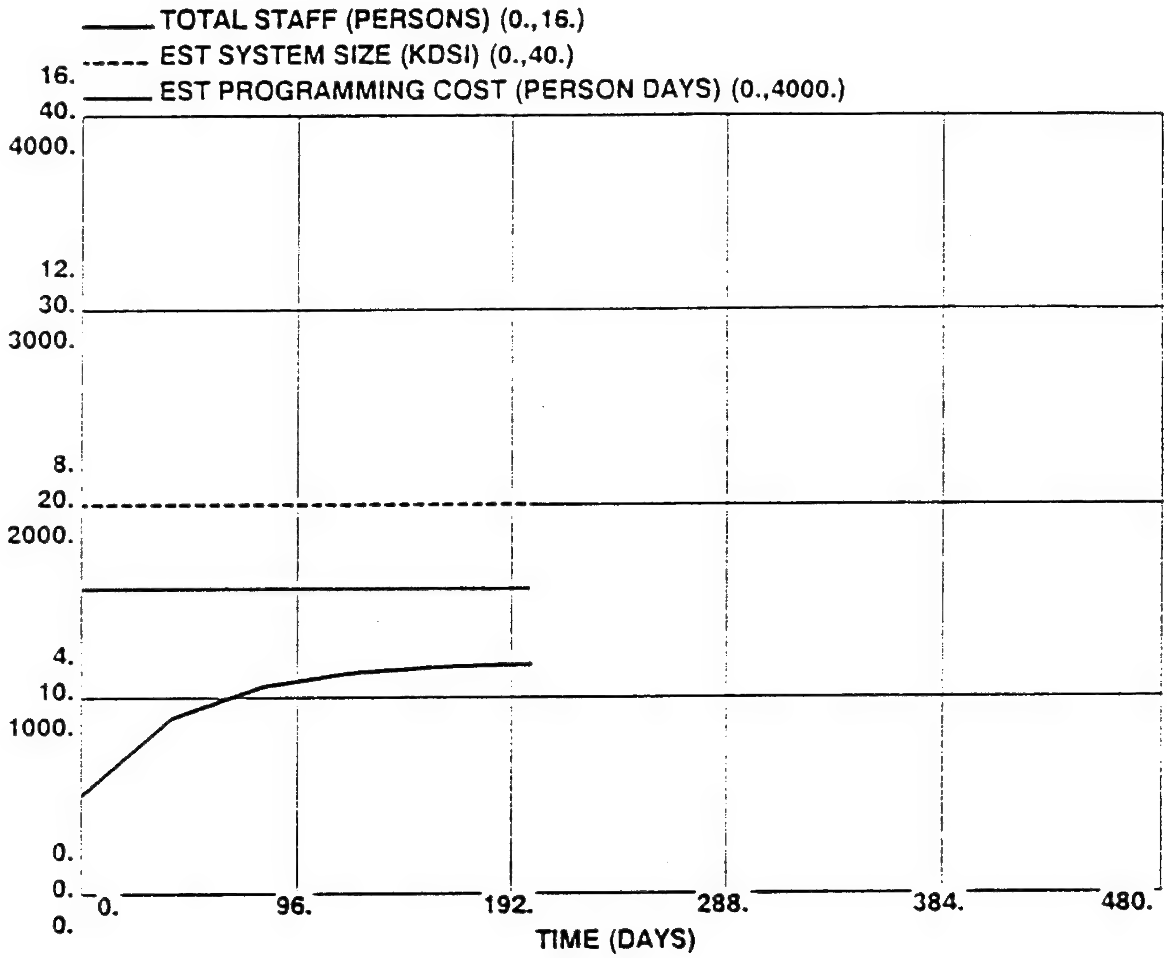
This report recaps the **TOTAL Person-Days Expended to Date** and provides a breakdown of the number of person days expended on both the QA and programming activities.

In the top section, this report gives cumulative defect data (i.e. from start of programming phase to current time). The bottom section shows data for the last 40 day period only.

Historically, the **Defect Density** (i.e. number of defects detected during programming divided by the number of KDSI developed) has ranged from 5 - 20 Defects/KDSI.

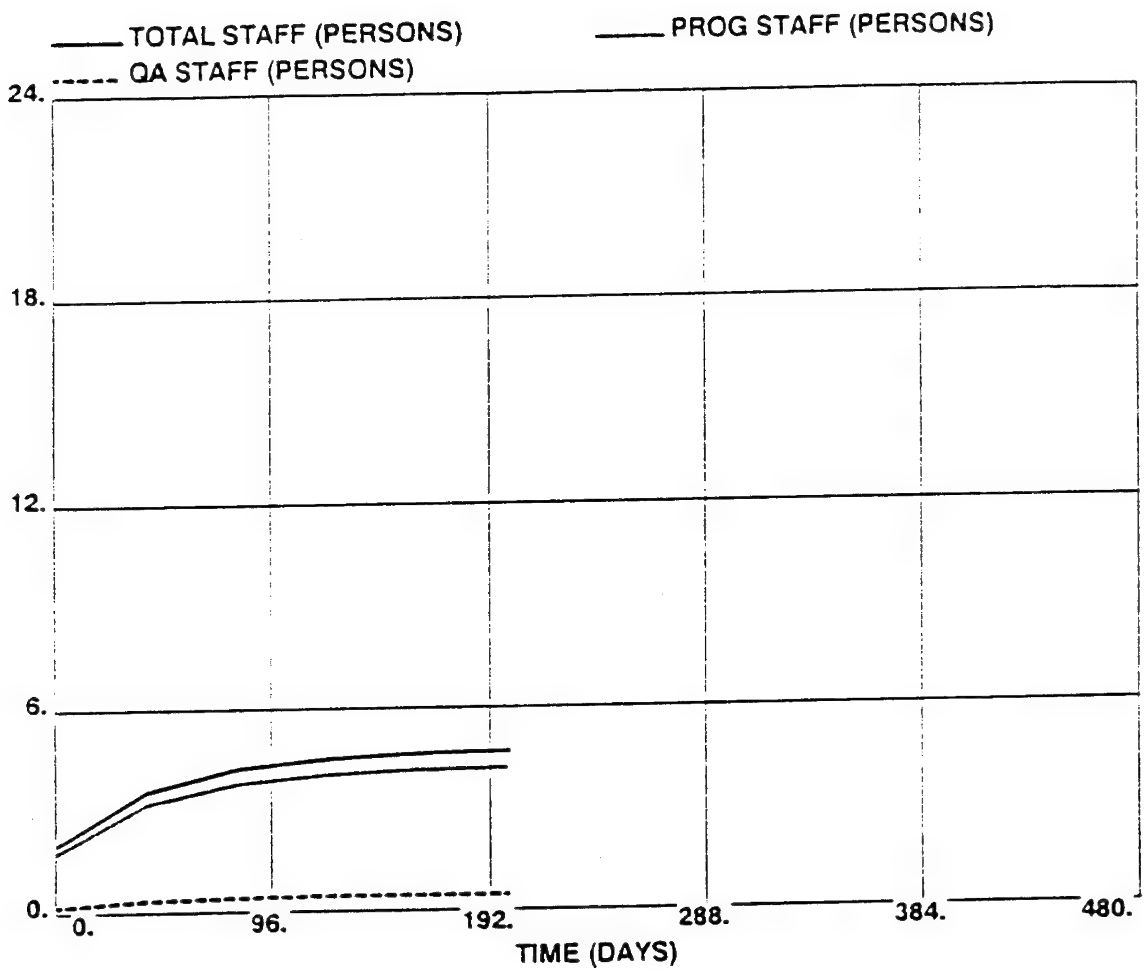
Comparing the aggregate data and the data for the last period can indicate trends.

Graph 4 (PROJECT SIZE & STATUS GRAPH)



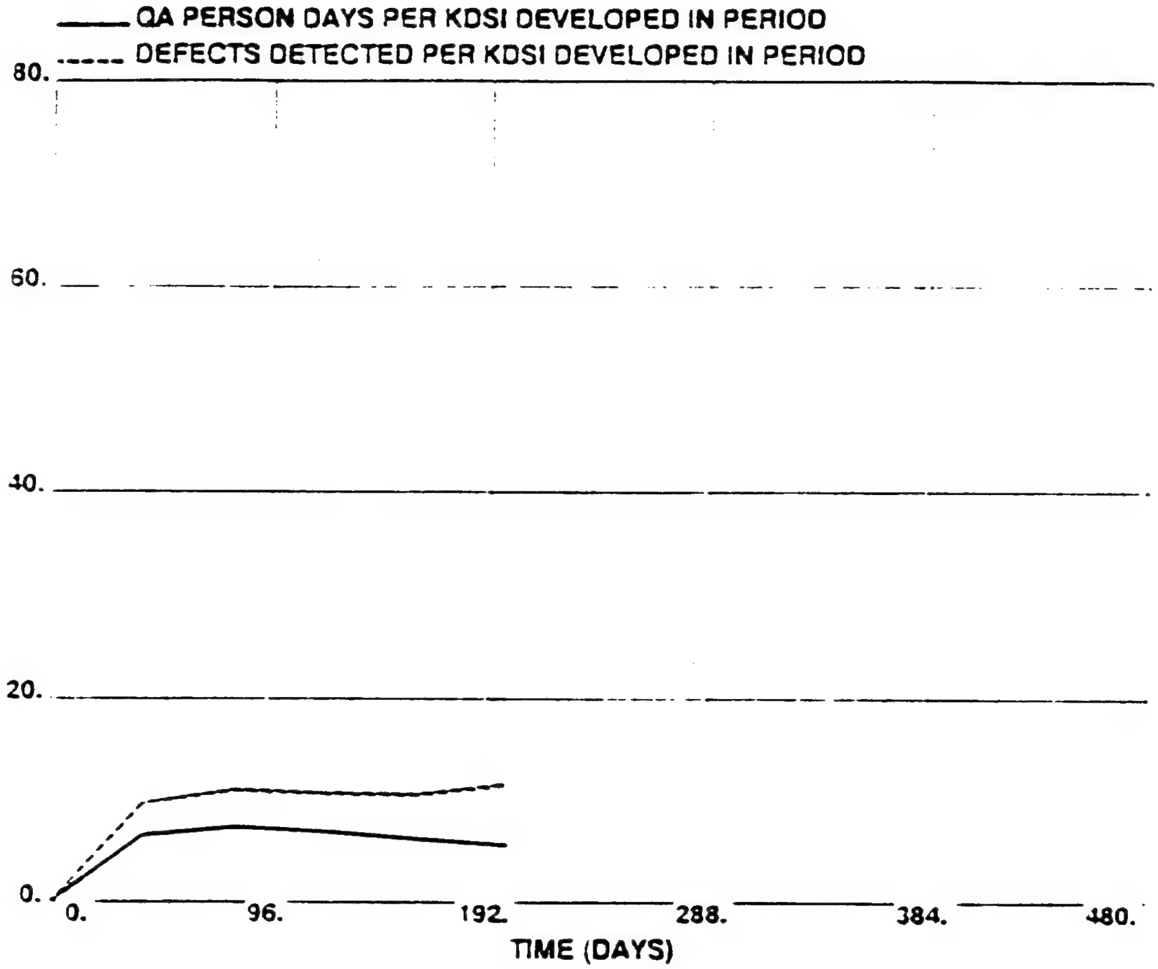
This graph shows how the total staff level and the estimates of system size and programming cost are changing over time.

Graph 5 (STAFFING GRAPH)



This graph shows how the level of the total staff, programming staff, and QA staff is changing over time.

Graph 6 (DEFECT GRAPH)



This graph shows how "QA Person Days per KDSI Developed in Period" and the "Defects Detected per KDSI Developed in Period" are changing over time.

APPENDIX L. MASTER PROJECT QUESTIONNAIRE

PROJECT QUESTIONNAIRE XXX

Your Name: ________________________________
SMC No.: ________________________________

1. In making your decisions, how much weight out of 100 points did you accord to the following goals? (The numbers should total 100 points.)

Cost [**or QUALITY**] ____

Schedule ____
100

2. Describe (in words, numbers, equation, etc.) what decision rule you followed in deciding on the overall staffing level in this project:

____

____

____

____

3. Describe (in words, numbers, equation, etc.) how you allocated staff between programming and quality assurance.

____

____

____

____

4. Please try to elaborate on the thinking process you went through in making your decisions in this project (use back of page if necessary):

____

____

____

5. How clear were the instructions regarding the task?

1	2	3	4	5	6	7	8	9
Not at all Clear								Very Clear

6. To what extent was the graphical information provided on the progress of the project helpful in improving your own decisions?

1	2	3	4	5	6	7	8	9
Not at all Helpful								Very Helpful

7. To what extent were the reports on the progress of the project helpful in improving your own decisions?

1	2	3	4	5	6	7	8	9
Not at all Helpful								Very Helpful

8. In the project that you just completed, did you

(a) Use the PROJECT STATUS report (Y/N)? ________

(b) If you did, please describe how you used the information.

____

____

____

9. In the project that you just completed, did you

(a) Use the STAFFING LEVEL report (Y/N)? ________

(b) If you did, please describe how you used the information.

____

____

____

10. In the project that you just completed, did you

(a) Use the DEFECT report (Y/N)? ________

(b) If you did, please describe how you used the information.

____

____

____

11. In the project that you just completed, did you

(a) Use the PROJECT STATUS graph (Y/N)? ________

(b) If you did, please describe how you used the information.

____

____

____

12. In the project that you just completed, did you

(a) Use the STAFFING LEVEL graph (Y/N)? ________

(b) If you did, please describe how you used the information.

____

____

____

13. In the project that you just completed, did you

(a) Use the DEFECT graph (Y/N)? ________

(b) If you did, please describe how you used the information.

____

____

____

14. Have you in the past participated in project management (Y/N)? ___

If YES, to what extent was the task in this simulation similar to your previous experience?

1	2	3	4	5	6	7	8	9
Not at all Similar								Very Similar

15. How interesting was the task you just performed?

1	2	3	4	5	6	7	8	9
Not at all Interesting								Very Interesting

16. How serious were you in performing the task?

1	2	3	4	5	6	7	8	9
Not at all Serious								Very Serious

17. How clear were the instructions regarding the task, generally?

1	2	3	4	5	6	7	8	9
Not at all Clear								Very Clear

18. How easy was the simulation to use?

1	2	3	4	5	6	7	8	9
Not at all Easy								Very Easy

19. Please give us some information about yourself.

(a) Curriculum enrolled in: ______________________

(b) Age ______

(c) Sex ______

(d) Full time work experience (in years) ______

(e) How long ago (in years) did you complete your undergraduate education? ______

(f) How familiar are you with computers, generally?

1	2	3	4	5	6	7	8	9
Not at all Familiar								Very Familiar

(g) How many hours (per week) do you use computers?

____

20. Your general comments regarding the simulation:

____

____

____

____

____

*** END OF SIMULATION ***

Thank you for your participation.

APPENDIX M. POPULATION RANDOMIZATION WORKSHEETS

Random Number Assignment:

Bae, K.	607
Chou, M.	917
Franklin, B.	038
Haffey, P.	715
Hernandez, L.	086
Jo, J.	812
Kelly, James	255
McGibbon, H.	868
McQuay, D.	639
Michal, T.	382
Monroe, W.	465
Nault, M.	582
Oneill, T.	138
Onorati, A.	380
Pemberton, L.	373
Prell, M.	660
Robillard, S.	275
Robinson, J.	978
Sears, G.	781
Slocumb, C.	873
Staten, R.	080
Swain, W.	222
Tharpe, G.	126
Trepanier, D.	473
Wilcox, R.	009
Barnum, T.	431
Berry, E.	231
Bitzer, S.	547
Callaghan, V.	574
Cragmiles, R.	652
Davis, R.	383
Downs, M.	667
Emde, C.	319
Emswiler, T.	081
Encinas, T.	941
Gregorie, J.	932
Hodges, J.	550
Howard, L.	451
Humphries, T.	075
Johnson, S.	184
Kelly, John	434
King, A.	471
Lamb, V.	551
Langhorne, W.	333
Larochelle, L.	889
Lewis, J.	895
Mancano, V.	604
Russ, K.	930
Weiss, K.	971

Project Assignment:

Wilcox, R.	009	A11
Franklin, B.	038	A12
Humphries, T.	075	A21
Staten, R.	080	A22
Emswiler, T.	081	B11
Hernandez, L.	086	B12
Tharpe, G.	126	B21
Oneill, T.	138	B22
Johnson, S.	184	A11
Swain, W.	222	A12
Berry, E.	231	A21
Kelly, James	255	A22
Robillard, S.	275	B11
Emde, C.	319	B12
Langhorne, W.	333	B21
Pemberton, L.	373	B22
Onorati, A.	380	A11
Michal, T.	382	A12
Davis, R.	383	A21
Barnum, T.	431	A22
Kelly, John	434	B11
Howard, L.	451	B12
Monroe, W.	465	B21
King, A.	471	B22
Trepanier, D.	473	A11
Bitzer, S.	547	A12
Hodges, J.	550	A21
Lamb, V.	551	A22
Callaghan, V.	574	B11
Nault, M.	582	B12
Mancano, V.	604	B21
Bae, K.	607	B22
McQuay, D.	639	A11
Cragmiles, R.	652	A12
Prell, M.	660	A21
Downs, M.	667	A22
Haffey, P.	715	B11
Sears, G.	781	B12
Jo, J.	812	B21
McGibbon, H.	868	B22
Slocumb, C.	873	A11
Larochelle, L.	889	A12
Lewis, J.	895	A21
Chou, M.	917	A22
Russ, K.	930	B11
Gregorie, J.	932	B12
Encinas, T.	941	B21
Weiss, K.	971	B22
Robinson, J.	978	A11

APPENDIX N. SEATING CHARTS

Seating Chart
(Morning)

IN-224

(Front)

Tharpe	McQuay	Jo	Staten	Pemberton	Onorati
	X	Chou	X	Franklin	Robinson
Nault		Haffey		Robillard	down

IN-250

(Front)

Michal		Sears		Slocumb		Swain
	Monroe		McGibbon		Kelly James	Oneill
Wilcox	Hernandez	X	Prell	Trepanier		
Bae	X	X	X	X		

X = Computer unavailable

Seating Chart
(Afternoon)

IN-224

(Front)

Mancano	Humphries	Weiss	Larochelle	Kelly, John	Lamb
	X	Hodges	X		
Emde	Berry	Callaghan	Davis	Encinas	X

IN-250

(Front)

King		Johnson		Langhorne		Lewis
	Barnum	Gregoire	Downs		Bitzer	Howard
Cragmiles		X		Emswiler		
Russ	X	X	X	X		

X = Computer unavailable

APPENDIX O. KEY TO DATA FILE VARIABLES

Format explanation of PERFORM.DAT file:

One line containing 5 identifiers plus 10 variables captured at project completion:

Name	Subject's name
SMC	Student Mail Center Box Number
Project	A initially underestimated, B initially overestimated
Goal	1 = Cost and Schedule, 2 = Quality and Schedule
Order	The order that the goals were listed on the instructions (1 or 2)
FNCOST	Final Cost (in Man Days)
FNTIME	Final Cumulative Time (Days)
FNERR	Final Errors Remaining Undetected
FNERG	Final Cumulative Errors Generated
FNERD	Final Cumulative Errors Detected
FNERES	Final Cumulative Errors Excaping Detection
FNPRDT	Final Percentage of Errors Detected
FNQAMD	Final Cumulative Quality Assurance Man Days
FNTRMD	Final Cumulative Training Man Days
FNRWMD	Final Cumulative Rework Man Days

Format explanation of PROCESS.DAT

One line containing 6 identifiers, 26 output variables, then 4 decision variables captured at project start and every 40 workdays until project completion:

Name	Subject's name
SMC	Student Mail Center Box Number
Project	A increased in size, B decreased in Size
Goal	1 = Cost and Schedule, 2 = Quality and Schedule
Order	The order that the goals were listed on the instructions (1 or 2)
Day	The period that the decisions were made
IPRJSZ	Initial Project Size (in Delivered Source Instructions)
TOTMDO	Programming Phase Cost (in Man Days)
TDEV	Programming Phase Duration (Development Time in Days)
PJBSZT	Updated Est of System Size (in DSI)
FNERR	Final Errors Remaining Undetected
FNERG	Final Cumulative Errors Generated
TIMERM	Time Remaining
PRCMPL	Percent DSI Reported Complete
CMDSI	Total DSI Completed to Date
CUMMD	Total Person Days Expended to Date
RPPROD	Reported Productivity (in DSI/Person Day)
FTEQWF	Current Total Staff Size (in People)
CRDVWF	Staff Allocated to Programming (in People)
CRQAWF	Staff Allocated to QA (in People)
FRWFEX	Percent of Workforce that is Experienced
CMQAMD	QA Person Days Expended to Date
CMERD	Total Defects Detected
PRQAMD	QA Person Days Expended Last 40 Days
PRERD	Defects Detected Last 40 Days
PRDFDS	Defect Density Observed Last 40 Days
PRTKDV	DSI Developed Last 40 Days
TOTMD1	Programming Phase Cost (in Man Days)
WFS	Total Workforce Sought
CRRWWF	Current Rework Workforce (in People)
AFMDPJ	Actual Fraction of Man Days on Project
SCHPR	Schedule Pressure
WFS2	Total Workforce Requested
FRMPQ1	Fraction of Workforce devoted to Quality Assurance (Percent)
JBSZMD	Last Est of Programming Phase Cost (in Person Days)
SCHCDT	Last Est of Prog Phase Duration (start-end in Days)

Format explanation of Questionnaire/Demographic Data:

Q1S	Question 1 Schedule Percent (All subjects)
Q1Q	Question 1 Quality Percent (value only for Goal 2)
Q1C	Question 1 Cost Percent (value only for Goal 1)
Q5	Question 5 Response (1-9)
Q6	Question 6 Response (1-9)
Q7	Question 7 Response (1-9)
Q8	Question 8 Response (0/1 1=Yes 0=No)
Q9	Question 9 Response (0/1 1=Yes 0=No))
Q10	Question 10 Response (0/1 1=Yes 0=No)
Q11	Question 11 Response (0/1 1=Yes 0=No)
Q12	Question 12 Response (0/1 1=Yes 0=No)
Q13	Question 13 Response (0/1 1=Yes 0=No)
Q14	Question 14 Response (0-9 0=No, 1-9 indicate yes and the value)
Q15	Question 15 Response (1-9)
Q16	Question 16 Response (1-9)
Q17	Question 17 Response (1-9)
Q18	Question 18 Response (1-9)
CURRIC	Curriculum number or abbreviation
AGE	Age (years)
SEX	M=Male, F=Female
WKEXP	Work Experience (Years)
EDAGO	Years since undergraduate education was completed
CFAM	Computer familiarity (1-9)
CHRSWK	Computer hours per week
GRADE	Numeric grade received in IS-4300 course

APPENDIX P. PERFORMANCE /DEMOGRAPHIC DATA SETS

Performance and Demographic data for all subjects 1

OBS	LNAME	SMC	PROJECT	GOALS	ORDER	FNCOST	FNSKED	FNERR	FNERG	FNERD	FNERES	FNPRDT	FNQAMD
1	gregoire	2216	A	1	1	1608.09	345.5	727.63	534.54	307.03	227.52	57.44	197.26
2	JOHNSON	1113	A	1	1	1323.69	345.0	3583.83	616.99	229.87	387.12	37.26	105.76
3	mcquay	2039	A	1	1	1388.10	240.0	1266.51	593.75	297.04	296.70	50.03	152.96
4	onorati	2662	A	1	1	1506.37	287.0	1267.46	539.69	193.01	346.69	35.76	127.26
5	SLOCUMB	2569	A	1	1	1307.80	255.5	2290.13	669.95	309.61	360.33	46.21	130.78
6	trepanie	3032	A	1	1	1803.14	270.5	659.41	563.55	379.19	184.36	67.29	308.21
7	Wilcox	2484	A	1	1	1546.32	294.0	1940.76	542.92	212.08	330.83	39.06	130.41
8	Bitzer	2458	A	1	2	1387.75	260.5	1331.26	576.21	254.12	322.09	44.10	148.50
9	Craigmil	2669	A	1	2	1462.60	289.5	1778.51	622.97	304.10	318.88	48.81	155.26
10	franklin	2972	A	1	2	1728.56	273.5	908.61	636.08	409.28	226.79	64.35	263.67
11	LaRochel	2757	A	1	2	1318.54	307.5	2013.30	600.67	283.47	317.21	47.19	131.85
12	michal	2120	A	1	2	1440.13	284.0	2006.34	547.61	219.38	328.23	40.06	123.87
13	Swain	2596	A	1	2	1688.58	403.0	914.96	523.12	340.71	182.41	65.13	276.81
14	BERRY	2971	A	2	1	2175.20	285.0	674.36	625.00	481.72	143.28	77.07	503.52
15	Davis	2525	A	2	1	2432.51	282.0	660.77	606.47	467.19	139.28	77.03	597.79
16	Hodges	2009	A	2	1	1779.37	343.5	1014.60	550.10	365.09	185.02	66.37	310.63
17	humphrie	2722	A	2	1	1581.31	467.5	670.15	579.19	344.19	235.00	59.43	290.39
18	lewis	2973	A	2	1	1883.90	312.0	683.64	549.40	350.05	199.35	63.71	361.40
19	Prell	2776	A	2	1	1667.56	323.0	656.67	551.21	388.78	162.43	70.53	278.28

OBS	FNTRMD	FNRWMD	Q1S	Q1Q	Q1C	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	CURRIC	AGE	SEX	WKEXP	EDAGO	CFAM	CHRSWK	GRADE
1	95.16	245.91	50	0	50	8	1	7	1	1	1	0	0	0	0	9	9	9	8	ITM	34	M	10	11	7	20	3.7
2	65.32	145.04	50	0	50	9	1	9	1	1	1	0	0	0	0	9	9	9	9	ITM	32	F	8	8	5	12	3.7
3	98.38	199.13	75	0	25	9	7	8	1	1	1	0	1	1	0	9	8	9	9	ITM	34	M	16	6	9	45	3.7
4	93.58	169.81	50	0	50	9	3	9	1	1	1	0	1	0	0	7	9	9	8	ITM	32	M	10	10	5	10	3.0
5	94.88	171.05	55	0	45	7	7	8	1	1	1	1	1	1	4	7	7	7	6	365	28	M	11	5	7	12	2.3
6	129.48	297.11	40	0	60	8	5	7	1	1	1	1	1	1	0	9	7	9	8	ITM	39	M	18	15	6	20	4.0
7	94.82	169.30	75	0	25	8	3	8	1	1	1	1	1	1	0	9	9	8	9	ITM	37	M	15	15	7	10	3.3
8	89.88	187.03	65	0	35	8	3	8	1	1	1	0	0	0	0	6	9	8	7	ITM	32	F	12	10	6	15	3.7
9	109.28	205.91	50	0	50	9	4	9	1	1	1	1	1	1	5	9	9	9	9	ITM	44	M	21	22	6	13	3.3
10	134.45	296.56	45	0	55	9	7	9	1	1	1	1	1	1	9	9	9	9	9	ITM	40	F	15	15	9	18	3.3
11	82.68	173.39	50	0	50	9	3	9	1	1	1	0	0	0	8	8	9	9	9	ITM	43	M	20	20	8	21	4.0
12	89.38	162.22	60	0	40	9	1	9	1	1	1	0	0	0	0	9	9	9	9	ITM	28	F	6	6	4	30	3.0
13	84.22	271.66	80	0	20	6	5	8	1	1	1	0	0	0	0	4	8	3	8	ITM	46	M	26	24	8	20	3.0
14	195.54	353.43	30	70	0	7	7	7	1	1	1	1	1	1	3	6	6	7	6	ITM	33	M	12	11	7	5	3.7
15	237.13	365.56	60	40	0	9	8	9	1	1	1	0	0	1	0	9	9	9	7	ITM	36	M	18	9	9	17	3.3
16	112.14	285.62	70	30	0	9	1	9	1	1	1	0	0	0	0	9	9	9	9	ITM	32	M	10	4	9	15	4.0
17	62.39	251.62	25	75	0	9	9	9	1	0	1	0	0	1	0	7	9	9	5	ITM	33	M	10	10	7	10	3.0
18	122.92	281.89	40	60	0	6	6	7	1	0	1	1	0	1	0	4	7	7	6	ITM	34	M	17	11	3	5	3.7
19	104.82	292.95	40	60	0	7	8	8	1	1	1	1	1	1	0	9	9	8	6	ITM	29	M	8	8	6	30	4.0

OBS	LNAME	SMC	PROJECT	GOALS	ORDER	FNCOST	FNSKED	FNERR	FNERG	FNERD	FNERES	FNPRDT	FNQAMD
20	Barnum	1168	A	2	2	1635.37	343.0	663.91	552.75	391.96	160.80	70.91	282.88
21	chou	3145	A	2	2	2129.77	307.0	651.93	563.74	421.65	142.09	74.80	491.54
22	downs	1095	A	2	2	2029.80	283.0	1127.32	599.79	413.60	186.19	68.96	304.54
23	jameskel	2983	A	2	2	2795.41	262.5	606.58	607.57	474.44	133.14	78.09	741.07
24	lamb	2147	A	2	2	1549.55	346.5	650.49	667.82	465.06	202.76	69.64	362.97
25	staten	2743	A	2	2	1896.74	275.0	845.50	731.88	575.12	156.75	78.58	420.78
26	Callagha	3036	B	1	1	1162.50	272.5	9596.59	555.04	0.00	555.04	0.00	0.00
27	Emswiler	2157	B	1	1	1796.82	242.0	825.87	577.88	331.40	246.47	57.35	233.01
28	haffey	1489	B	1	1	1663.12	239.5	882.28	565.93	288.54	277.39	50.99	175.39
29	johnkell	2723	B	1	1	1706.80	204.5	2401.36	615.36	214.26	401.10	34.82	122.98
30	Robillar	2816	B	1	1	1967.04	256.5	1032.58	600.35	429.60	170.75	71.56	374.52
31	russ	1165	B	1	1	1715.14	241.5	1199.40	578.44	336.17	242.27	58.12	206.95
32	emde	1867	B	1	1	1621.33	220.0	1305.05	585.97	194.69	391.28	33.22	121.32
33	hernande	2666	B	1	2	1845.73	246.5	1275.51	587.63	296.99	290.64	50.54	249.91
34	howard	1633	B	1	2	1852.41	230.5	1615.55	597.36	375.56	221.80	62.87	232.05
35	Nault	2683	B	1	2	1786.96	315.0	1352.10	554.27	328.03	226.24	59.18	230.44
36	robinson	2016	B	1	2	1478.70	238.5	2386.62	564.62	135.96	428.66	24.08	78.13
37	Sears	1757	B	1	2	1833.37	257.5	1088.05	574.87	380.37	194.50	66.17	270.63
38	Encinias	3043	B	2	1	2302.91	245.0	727.00	600.12	433.69	166.43	72.27	389.80

OBS	FNTRMD	FNRWMD	Q1S	Q1Q	Q1C	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	CURRIC	AGE	SEX	WKEXP	EDAGO	CFAM	CHRSWK	GRADE
20	95.89	288.78	35	65	0	9	2	9	1	1	1	0	0	0	0	8	9	9	9	ITM	34	M	10	10	2	5	4.0
21	153.12	345.84	60	40	0	8	8	9	1	1	1	0	0	1	0	9	9	9	8	ITM	39	M	1	1	4	13	3.3
22	190.62	320.34	50	50	0	9	5	9	1	1	1	1	0	1	0	9	9	9	9	ITM	31	M	10	10	9	15	4.0
23	279.83	408.62	50	50	0	9	5	9	1	1	1	1	1	1	1	9	9	9	9	ITM	38	M	16	16	7	8	4.0
24	80.76	292.74	60	40	0	8	5	8	1	1	1	0	1	1	0	5	8	8	8	ITM	25	F	5	5	6	10	3.7
25	149.91	363.66	40	60	0	8	3	9	1	1	1	1	0	1	5	3	9	8	9	ITM	35	M	11	13	5	12	2.3
26	77.28	0.00	60	0	40	9	7	9	1	1	0	1	1	0	0	9	9	9	8	ITM	32	F	10	10	5	20	3.7
27	146.99	262.84	60	0	40	9	4	9	1	1	1	0	0	0	5	9	9	9	9	ITM	28	F	6	6	7	12	2.7
28	127.59	238.67	30	0	70	9	7	9	1	1	1	1	0	1	5	8	8	9	8	ITM	33	M	10	10	7	6	4.0
29	172.89	161.51	60	0	40	8	6	9	1	1	1	1	0	0	0	8	8	8	8	ITM	34	M	12	12	5	10	3.3
30	168.24	319.94	60	0	40	5	4	7	1	1	1	0	0	0	0	5	9	5	9	ITM	32	M	8	8	5	12	3.3
31	138.75	256.80	50	0	50	8	2	7	1	1	1	0	0	0	0	9	9	8	8	ITM	31	F	11	7	6	11	3.7
32	138.13	155.25	50	0	50	8	2	7	1	1	1	0	0	0	0	9	9	8	8	ITM	31	F	11	7	6	11	3.0
33	159.77	233.20	75	25	0	4	5	7	1	1	1	0	0	0	1	8	9	5	4	ITM	36	M	14	13	9	24	3.7
34	168.69	286.81	60	0	40	9	2	9	1	1	1	0	0	0	0	9	9	9	8	ITM	45	M	24	24	7	20	3.0
35	122.86	264.41	45	0	55	9	9	9	1	1	1	1	1	1	0	9	8	9	9	ITM	38	M	16	16	5	6	3.7
36	106.01	111.04	20	0	80	9	8	9	1	1	1	0	1	0	0	9	9	9	9	ITM	39	M	16	16	5	6	2.7
37	145.13	296.91	90	0	10	6	1	9	1	1	1	0	0	0	0	9	9	7	9	ITM	31	M	10	10	5	7	4.0
38	218.06	368.89	60	40	0	8	9	7	1	1	1	1	1	1	0	8	8	8	9	ITM	29	M	7	7	7	12	3.7

OBS	LNAME	SMC	PROJECT	GOALS	ORDER	FNCOST	FNSKED	FNERR	FNERG	FNERD	FNERES	FNPRDT	FNQAMD
39	jo	1922	B	2	1	1829.38	239.5	1471.04	582.18	342.22	239.96	58.78	257.37
40	langhorn	2464	B	2	1	1932.11	318.0	556.65	541.47	405.64	135.83	74.91	495.20
41	Mancano	2754	B	2	1	2251.98	234.5	707.93	602.17	445.68	156.49	74.01	404.99
42	Monroe	1640	B	2	1	1760.00	237.0	701.58	621.09	443.65	177.44	71.43	299.85
43	tharpe	2705	B	2	1	2090.71	238.0	802.17	606.77	395.89	210.88	65.25	398.03
44	bae	1767	B	2	2	1756.83	243.5	1907.44	581.54	295.60	285.94	50.83	199.81
45	King	2684	B	2	2	1981.26	278.5	579.50	568.99	429.90	139.08	75.56	462.89
46	McGibbon	2770	B	2	2	1734.86	227.5	1655.26	585.65	290.68	294.97	49.63	169.98
47	O'Neill	2685	B	2	2	2095.24	239.5	822.37	595.88	382.09	213.79	64.12	343.33
48	Pemberto	2687	B	2	2	1698.32	297.0	1503.58	551.84	289.15	262.70	52.40	192.44
49	weiss	1988	B	2	2	2369.53	257.5	640.76	594.74	431.99	162.76	72.63	512.68

OBS	FNTRMD	FNRWMD	Q1S	Q1Q	Q1C	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	CURRIC	AGE	SEX	WKEXP	EDAGOM	CFAM	CHRSWK	GRADE
39	150.31	265.37	45	55	0	6	8	8	1	1	1	1	0	1	1	9	8	4	9	ITM	29	M	6	4	8	10	3.3
40	120.32	318.25	45	55	0	9	5	7	1	1	0	0	0	0	0	8	8	9	9	ITM	26	F	3	4	6	18	2.3
41	212.31	371.96	75	25	0	9	5	9	1	1	1	0	0	1	0	9	9	9	9	ITM	29	M	6	7	7	20	3.7
42	143.81	315.81	45	55	0	9	4	9	1	1	1	1	1	1	0	5	5	5	5	ITM	31	M	14	5	5	4	3.7
43	186.54	317.31	75	0	25	9	2	9	1	1	1	0	0	0	0	9	9	9	9	ITM	32	M	11	11	5	8	3.3
44	145.20	226.72	70	30	0	5	2	8	1	1	1	0	0	0	0	7	9	4	3	ITM	38	M	18	18	5	10	4.0
45	146.83	330.58	50	50	0	8	8	8	1	1	1	1	1	1	0	9	9	9	7	ITM	28	M	7	7	9	50	4.0
46	149.35	227.82	50	50	0	9	7	9	1	1	1	1	1	1	0	9	9	9	7	ITM	33	M	17	8	9	28	2.0
47	189.79	312.52	75	25	0	8	5	8	1	1	1	0	0	1	0	5	5	5	5	ITM	30	M	8	8	5	15	4.0
48	112.48	232.90	40	60	0	9	8	9	1	1	1	1	1	1	0	9	9	9	8	ITM	29	M	7	7	8	7	3.7
49	222.56	359.81	50	50	0	9	2	9	1	1	1	0	0	0	0	9	9	9	8	ITM	38	F	20	5	7	30	3.3

------------------------------ PROJECT=A GOALS=1 ------------------------------

Variable	N	Mean	Std Dev	Minimum	Maximum
FNCOST	13	1500.74	164.4731389	1307.80	1803.14
FNSKED	13	296.5769231	44.6210181	240.0000000	403.0000000
FNERR	13	1591.44	805.2887142	659.4100000	3583.83
FNERG	13	582.1576923	45.3158225	523.1200000	669.9500000
FNERD	13	287.6069231	65.2009571	193.0100000	409.2800000
FNERES	13	294.5507692	66.9175653	182.4100000	387.1200000
FNPRDT	13	49.4376923	10.9052213	35.7600000	67.2900000
FNQAMD	13	173.2769231	66.7709393	105.7600000	308.2100000
FNTRMD	13	97.0392308	18.5185414	65.3200000	134.4500000
FNRWMD	13	207.2400000	52.7317087	145.0400000	297.1100000
Q1S	13	57.3076923	12.6845353	40.0000000	80.0000000
Q1Q	13	0	0	0	0
Q1C	13	42.6923077	12.6845353	20.0000000	60.0000000
Q5	13	8.3076923	0.9473309	6.0000000	9.0000000
Q6	13	3.8461538	2.2303271	1.0000000	7.0000000
Q7	13	8.3076923	0.7510676	7.0000000	9.0000000
Q8	13	1.0000000	0	1.0000000	1.0000000
Q9	13	1.0000000	0	1.0000000	1.0000000
Q10	13	1.0000000	0	1.0000000	1.0000000
Q11	13	0.3846154	0.5063697	0	1.0000000
Q12	13	0.5384615	0.5188745	0	1.0000000
Q13	13	0.4615385	0.5188745	0	1.0000000
Q14	13	2.0000000	3.3416563	0	9.0000000
Q15	13	8.0000000	1.5811388	4.0000000	9.0000000
Q16	13	8.5384615	0.7762500	7.0000000	9.0000000
Q17	13	8.2307692	1.6908502	3.0000000	9.0000000
Q18	13	8.3076923	0.9473309	6.0000000	9.0000000
AGE	13	36.0769231	5.9366312	28.0000000	46.0000000
WKEXP	13	14.4615385	5.7244415	6.0000000	26.0000000
EDAGO	13	12.8461538	6.2695847	5.0000000	24.0000000
CFAM	13	6.6923077	1.5483656	4.0000000	9.0000000
CHRSWK	13	18.9230769	9.6476382	10.0000000	45.0000000
GRADE	13	3.3846154	0.4827804	2.3000000	4.0000000

------------------------------ PROJECT=A GOALS=2 ------------------------------

Variable	N	Mean	Std Dev	Minimum	Maximum
FNCOST	12	1963.04	374.9267668	1549.55	2795.41
FNSKED	12	319.1666667	54.8905247	262.5000000	467.5000000
FNERR	12	742.1600000	165.5405795	606.5800000	1127.32
FNERG	12	598.7433333	55.6844898	549.4000000	731.8800000
FNERD	12	428.2375000	67.2432412	344.1900000	575.1200000
FNERES	12	170.5075000	31.2716512	133.1400000	235.0000000
FNPRDT	12	71.2600000	6.0995171	59.4300000	78.5800000
FNQAMD	12	412.1491667	145.7626236	278.2800000	741.0700000
FNTRMD	12	148.7558333	65.8980129	62.3900000	279.8300000
FNRWMD	12	320.9208333	46.0930915	251.6200000	408.6200000
Q1S	12	46.6666667	13.8717065	25.0000000	70.0000000
Q1Q	12	53.3333333	13.8717065	30.0000000	75.0000000
Q1C	12	0	0	0	0
Q5	12	8.1666667	1.0298573	6.0000000	9.0000000
Q6	12	5.5833333	2.5746433	1.0000000	9.0000000
Q7	12	8.5000000	0.7977240	7.0000000	9.0000000
Q8	12	1.0000000	0	1.0000000	1.0000000
Q9	12	0.8333333	0.3892495	0	1.0000000
Q10	12	1.0000000	0	1.0000000	1.0000000
Q11	12	0.5000000	0.5222330	0	1.0000000
Q12	12	0.3333333	0.4923660	0	1.0000000
Q13	12	0.8333333	0.3892495	0	1.0000000
Q14	12	0.7500000	1.6025548	0	5.0000000
Q15	12	7.2500000	2.2207697	3.0000000	9.0000000
Q16	12	8.5000000	1.0000000	6.0000000	9.0000000
Q17	12	8.4166667	0.7929615	7.0000000	9.0000000
Q18	12	7.5833333	1.5050420	5.0000000	9.0000000
AGE	12	33.2500000	3.8168288	25.0000000	39.0000000
WKEXP	12	10.6666667	4.8492424	1.0000000	18.0000000
EDAGO	12	9.0000000	4.0676104	1.0000000	16.0000000
CFAM	12	6.1666667	2.3290003	2.0000000	9.0000000
CHRSWK	12	12.0833333	6.9994589	5.0000000	30.0000000
GRADE	12	3.5833333	0.5271421	2.3000000	4.0000000

------------------------------ PROJECT=B GOALS=1 ------------------------------

Variable	N	Mean	Std Dev	Minimum	Maximum
FNCOST	12	1702.49	212.3740302	1162.50	1967.04
FNSKED	12	247.0416667	27.7426963	204.5000000	315.0000000
FNERR	12	2080.08	2422.50	825.8700000	9596.59
FNERG	12	579.8100000	18.6158168	554.2700000	615.3600000
FNERD	12	275.9641667	120.8316341	0	429.6000000
FNERES	12	303.8450000	115.2717197	170.7500000	555.0400000
FNPRDT	12	47.4083333	20.6720865	0	71.5600000
FNQAMD	12	191.2775000	98.9472637	0	374.5200000
FNTRMD	12	139.3608333	28.1319277	77.2800000	172.8900000
FNRWMD	12	215.6150000	92.2971860	0	319.9400000
Q1S	12	55.0000000	18.4637236	20.0000000	90.0000000
Q1Q	12	2.0833333	7.2168784	0	25.0000000
Q1C	12	42.9166667	21.9977616	0	80.0000000
Q5	12	7.7500000	1.7645499	4.0000000	9.0000000
Q6	12	4.7500000	2.6671401	1.0000000	9.0000000
Q7	12	8.3333333	0.9847319	7.0000000	9.0000000
Q8	12	1.0000000	0	1.0000000	1.0000000
Q9	12	1.0000000	0	1.0000000	1.0000000
Q10	12	0.9166667	0.2886751	0	1.0000000
Q11	12	0.3333333	0.4923660	0	1.0000000
Q12	12	0.2500000	0.4522670	0	1.0000000
Q13	12	0.1666667	0.3892495	0	1.0000000
Q14	12	0.9166667	1.9286516	0	5.0000000
Q15	12	8.4166667	1.1645002	5.0000000	9.0000000
Q16	12	8.7500000	0.4522670	8.0000000	9.0000000
Q17	12	7.9166667	1.5050420	5.0000000	9.0000000
Q18	12	8.0833333	1.3789544	4.0000000	9.0000000
AGE	12	34.1666667	4.6482320	28.0000000	45.0000000
WKEXP	12	12.3333333	4.7161875	6.0000000	24.0000000
EDAGO	12	11.5833333	5.1249538	6.0000000	24.0000000
CFAM	12	6.0000000	1.2792043	5.0000000	9.0000000
CHRSWK	12	12.0833333	6.1119605	6.0000000	24.0000000
GRADE	12	3.4000000	0.4670994	2.7000000	4.0000000

------------------------------ PROJECT=B GOALS=2 ------------------------------

Variable	N	Mean	Std Dev	Minimum	Maximum
FNCOST	12	1983.59	237.0237943	1698.32	2369.53
FNSKED	12	254.6250000	28.2715123	227.5000000	318.0000000
FNERR	12	1006.27	481.4582602	556.6500000	1907.44
FNERG	12	586.0366667	22.9055437	541.4700000	621.0900000
FNERD	12	382.1816667	61.8505517	289.1500000	445.6800000
FNERES	12	203.8558333	56.2527387	135.8300000	294.9700000
FNPRDT	12	65.1516667	9.9011091	49.6300000	75.5600000
FNQAMD	12	343.8641667	119.7285690	169.9800000	512.6800000
FNTRMD	12	166.4633333	37.9067627	112.4800000	222.5600000
FNRWMD	12	303.9950000	53.5688925	226.7200000	371.9600000
Q1S	12	56.6666667	13.5400640	40.0000000	75.0000000
Q1Q	12	41.2500000	17.8535711	0	60.0000000
Q1C	12	2.0833333	7.2168784	0	25.0000000
Q5	12	8.1666667	1.3371158	5.0000000	9.0000000
Q6	12	5.4166667	2.5746433	2.0000000	9.0000000
Q7	12	8.3333333	0.7784989	7.0000000	9.0000000
Q8	12	1.0000000	0	1.0000000	1.0000000
Q9	12	1.0000000	0	1.0000000	1.0000000
Q10	12	0.9166667	0.2886751	0	1.0000000
Q11	12	0.5000000	0.5222330	0	1.0000000
Q12	12	0.4166667	0.5149287	0	1.0000000
Q13	12	0.6666667	0.4923660	0	1.0000000
Q14	12	0.0833333	0.2886751	0	1.0000000
Q15	12	8.0000000	1.5374122	5.0000000	9.0000000
Q16	12	8.0833333	1.5050420	5.0000000	9.0000000
Q17	12	7.4166667	2.1933094	4.0000000	9.0000000
Q18	12	7.3333333	2.0150946	3.0000000	9.0000000
AGE	12	31.0000000	3.7416574	26.0000000	38.0000000
WKEXP	12	10.3333333	5.5650424	3.0000000	20.0000000
EDAGO	12	7.5833333	3.8247598	4.0000000	18.0000000
CFAM	12	6.7500000	1.5447860	5.0000000	9.0000000
CHRSWK	12	17.6666667	13.0058262	4.0000000	50.0000000
GRADE	12	3.4166667	0.6492420	2.0000000	4.0000000

APPENDIX Q. PROCESS DATA

Total Staff:

A1

														Mean	Std Dev
0	5	3.5	17	6	5	8	6	6	3.5	5	4	5	3.8	5.984615	3.539502
40	5	3.7	17	6	5	8	6	6	4.5	6	4	6	3.8	6.230769	3.448281
80	4.5	4.2	6	6	5	8	6	6	5	6	4	6	4.5	5.476923	1.087163
120	4.5	4.8	6	6	7	8	6	7	5.5	9	4	6	4.5	6.023077	1.448651
160	5	4.8	7	6	7	8	6	7	6.5	9	6	6	5	6.407692	1.208623
200	5	4.5	7	6	7	8	6	5.5	8.5	9	6	6	5	6.423077	1.397112
240	6.5	4.4	7	6	7	8	6	5	8.5	9	6	5.5	5	6.453846	1.403339
280	6.5	4.2		6			6		8.5		6	5	5	5.9	1.290626
320	6.5	4.1											5	5.2	1.212436
360													5	5	
400													5	5	

A2

													Mean	Std Dev
0	5	5	4	3	6	5	4	5	4.2	7	5	6	4.933333	1.069693
40	6	6	5	3.4	6	5	5	6	4.3	8	5	6.06	5.48	1.144505
80	6	8.1	5	4	7	5	5	8	5	8	5	8	6.175	1.538668
120	7	9	6	4	7	6	5	10	8.4	15	5	8	7.533333	2.947212
160	14	12	6	3.4	7	6.5	6	9	11.5	21	5	10	9.283333	4.860758
200	14	16	7	3.4	8	6.5	6	9	15	20	5	10	9.991667	5.115122
240	14	23.3	7	3.4	8	6.7	6	9	15	18	5	10	10.45	5.946045
280	11	19	7	5	6.5	6.7	6	9	15		5		9.02	4.673043
320			7	4.5		6	6				5		5.7	0.974679
360				3.5									3.5	
400				3.5									3.5	
440				3.5									3.5	

B1

													Mean	Std Dev
0	7	9	8	7.5	7.2	8.5	8	7.5	8	4	7	8.3	7.5	1.260591
40	6	9	9	7.5	8	8.5	10	7.5	9	5.5	8	8.3	8.025	1.282132
80	6	9	9	12	8	8.5	10	7.5	9	6.3	8	8.3	8.466667	1.591645
120	6	10	9	14	9	9.2	10	10.5	12	6.7	8	8.3	9.391667	2.179015
160	6	10	9	14	12	9.2	10	11.5	12	7.1	7	9.3	9.758333	2.356599
200	1.5	9	7	1.5	12	9.2	5.9	11.5	12	7.5	6	10	7.758333	3.62001
240	0.9	9	7	1.5	11	9.2		7.5		7.9		10	7.111111	3.575068
280	0.9									8.4			4.65	5.303301

B2

													Mean	Std Dev
0	9.5	8	7	9	9	12.1	7.6	8	10	9	5	10	8.683333	1.77397
40	9.5	10	7	10	9	12.1	8	8	10	9	6	10	9.05	1.618922
80	9.5	10	7	12	10	12.1	8	8	10	11	7	10	9.55	1.738076
120	15	10	7	16	10	12.1	10	9	10	13	7	10	10.75833	2.804366
160	15	10	7	16	9	12.1	10	9	10	13	7	14	11.00833	2.987994
200	15	9	7	12	9	12.1	9.5	9	10	12	7	18	10.8	3.233068
240	15	9	7				8	9		12	7	18	10.625	4.033343
280			7								7		7	0

Quality Assurance:

A1

														Mean	Std Dev
0	20	5	15	15	10	25	10	15	10	18	10	10	15	13.69230769	5.297556
40	20	5	15	15	10	25	10	15	12	18	10	9	15	13.76923077	5.27816
80	20	5	15	20	10	25	8	12.5	12	16	10	9	15	13.65384615	5.610201
120	10	5	0.12	5	10	12.5	8	12.5	12	16	10	9	15	9.624615385	4.361599
160	10	10	12	3	10	12.5	8	0.8	12	12	10	8	15	9.484615385	3.888411
200	15	10	10	3	10	12.5	8	10	12	15	10	8	15	10.65384615	3.375059
240	10	10	10	3	10	12.5	8	15	8	15	10	8	15	10.34615385	3.424085
280	5	10		3			8		4		10	8	17	8.125	4.454131
320	5	10											20	11.66666667	7.637626
360													20	20	
400													20	20	

A2

														Mean	Std Dev
0	20	20	15	35	25	20	20	20	15	25	30	17		21.83333333	5.982297
40	20	20	15	40	25	20	20	20	15	30	35	17.2		23.0975	7.936537
80	20	17	15	40	14	20	20	18	15	30	30	20		21.58333333	7.798116
120	23	25	15	20	10	15	15	20	16	30	35	20		20.33333333	7.062492
160	23	25	15	10	14	16	17	20	17	30	25	25		19.75	5.863989
200	23	30	15	10	20	16	17	22	17	22	15	25		19.33333333	5.399214
240	27	25	15	5	25	16	15	25	12	22	15	25		18.91666667	6.868351
280	20	25	15	10	24	14	17	40	10		12			18.7	9.177872
320			43	15		14	17				15			20.8	12.45793
360				15										15	
400				15										15	
440				15										15	

B1

														Mean	Std Dev
0	0	22	20	10	15	15	20	15	10	12	10	15		13.66666667	5.928871
40	0	22	17	10	15	15	7	15	15	13.5	7	15		12.625	5.764803
80	0	11	14	10	20	12	7	15	15	13.8	5	15		11.48333333	5.377027
120	0	10	7	5	20	12	5	0.2	15	13.5	5	15		8.975	6.278987
160	0	10	7	5	20	10	5	15	10	13.2	4	12		9.266666667	5.458827
200	0	11	5	10	20	11	10	20	10	12.8	3	12		10.4	5.923144
240	0	11	5	10	20	12		15		12.4		25		12.26666667	7.412152
280	0									12				6	8.485281

B2

														Mean	Std Dev
0	20	12	25	20	20	20	10	25	12	20	12	25		18.41666667	5.534328
40	20	14	28	20	20	20	11	25	12	20	12	25		18.91666667	5.599648
80	15	12	28	20	25	15	11	25	12	12	12	25		17.66666667	6.471382
120	15	13	28	15	15	10	11	20	10	12	12	25		15.5	5.869799
160	15	15	28	12.5	15	10	12	20	8	12	11	10		14.04166667	5.412353
200	18.5	17	28	25	10	40	12	25	6	25	10	20		19.70833333	9.578523
240	22.5	17	20				13	25		25	12	30		20.5625	6.276017
280			20								9			14.5	7.778175

Estimated Cost:

A1

														Mean	Std Dev
0	944	944	944	944	944	944	944	944	944	944	944	944	944	944	0
40	940	846	950	944	944	1165	1182	1000	944	964	944	950	944	978.2308	92.86204
80	940	945	950	944	944	1165	1264	980	1000	964	944	914	1600	1042.615	195.9883
120	1100	1146	990	944	944	1408	1499	980	1100	964	944	1420	1800	1172.231	273.6726
160	1400	944	1090	1681	944	1408	1716	1100	1250	964	944	1536	2250	1325.154	394.7104
200	1400	833	1409	1681	1000	1900	1810	1400	1350	2010	944	1573	2250	1504.615	425.3743
240	1700	862	1409	1681	1000	1900	1830	1400	1350	1800	1144	1501	2000	1505.923	354.2324
280	1700	1046		1681			1832		1450		1362	1449	2000	1565	299.8681
320	1700	1234											1800	1578	302.0795
360													1750	1750	
400													1700	1700	

A2

													Mean	Std Dev
0	944	944	944	944	944	944	944	944	944	944	944	944	944	0
40	969	944	944	944	1956	955	960	1000	956	1882	944	953	1117.25	375.1562
80	1000	1671	1000	1000	1791	1000	960	1350	1100	1882	944	973	1222.583	356.4077
120	1300	1841	1100	1000	1838	1200	1000	2000	1532	2451	944	973	1431.583	496.043
160	1900	2160	1200	944	2016	1400	1100	2000	1771	3401	944	975	1650.917	718.5645
200	2100	2372	1400	1400	2278	1600	1200	2200	2082	3401	944	975	1829.333	711.6836
240	2100	2462	1600	1200	2085	1700	1600	2200	2147	2964	944	975	1831.417	610.2377
280	2200	2502	1800	1200	1963	1700	1600	2200	2039		944		1814.8	475.7497
320			1903	900		1700	1650				944		1419.4	464.1021
360				944									944	
400				944									944	
440				944									944	

B1

													Mean	Std Dev
0	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	0
40	1800	1960	2300	1960	1960	1960	2851	2000	1960	1960	1960	1952	2051.892	275.4965
80	1800	1960	2300	1960	1960	1960	2712	2000	1960	1970	1960	1952	2041.125	239.078
120	1800	1960	2300	1960	1960	2173	2712	2000	1960	1970	1960	1820	2047.875	248.6248
160	1500	1960	2100	1960	2000	2173	2712	2000	1960	1970	1850	1900	2007.042	275.3124
200	1187	1960	1800	1720	2000	1780	1667	2000	1960	1980	1800	1900	1812.825	228.0173
240	1175	1960	1800	1720	1980	1760		2000		1990		1900	1809.444	260.2696
280	1175									1990			1582.5	576.292

B2

													Mean	Std Dev
0	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	0
40	2450	1960	1960	1960	1960	2991	1960	1954	1960	2200	1960	1960	2106.25	316.8063
80	2450	1960	1960	1960	1925	2880	2000	1954	1960	2350	1960	1960	2109.917	297.2237
120	2500	1960	1970	2884	1890	2222	2397	2000	1960	2500	1960	1960	2183.583	316.7039
160	2500	1960	1970	3035	1820	1800	2159	2000	1960	2500	1960	2600	2188.667	382.2737
200	3208	1960	2000	2495	1740	2200	1931	2000	1960	2350	1960	2600	2200.333	407.0234
240	3208	1960	2000				1877	2025		2350	1960	2600	2247.5	458.3617
280			2000								1960		1980	28.28427

Estimated Schedule:

A1

														Mean	Std Dev
0	272	272	272	272	272	272	272	272	272	272	272	272	272	272	0
40	270	229	272	272	272	272	334	272	272	272	272	320	272	277	25.29163
80	270	225	272	272	272	272	357	272	272	272	272	279	444	288.5385	54.40223
120	270	239	298	272	272	272	423	272	272	272	272	300	490	301.8462	71.47126
160	310	272	324	272	300	363	484	300	310	272	272	313	500	330.1538	76.423
200	340	185	334	272	300	363	510	280	335	350	272	314	480	333.4615	85.52935
240	360	196	334	280	300	330	516	280	335	330	300	297	480	333.6923	83.51884
280	360	249		280			516		300		329	286	480	350	97.61001
320	360	301											470	377	85.77296
360													470	470	
400													410	410	

A2

													Mean	Std Dev
0	272	272	272	272	272	272	272	272	272	272	272	272	272	0
40	272	300	272	272	326	272	272	272	272	272	272	273	278.9167	16.86016
80	272	272	293	280	288	285	272	272	272	272	272	273	276.9167	7.633161
120	292	272	293	280	301	285	272	272	272	272	272	273	279.6667	10.49098
160	292	272	300	272	330	300	272	285	272	272	272	273	284.3333	18.2823
200	315	272	300	280	348	320	272	300	300	272	272	273	293.6667	24.70309
240	315	272	320	225	329	320	272	300	286	272	272	273	288	29.88463
280	292	274	340	225	325	325	272	300	285		320		295.8	34.07117
320			350	200		325	272				360		301.4	66.14227
360				272									272	
400				250									250	
440				225									225	

B1

													Mean	Std Dev
0	272	272	272	272	272	272	272	272	272	272	272	272	272	0
40	272	272	320	272	272	272	325	272	272	273	272	271	280.4167	19.6906
80	272	272	320	272	272	272	358	265	272	274	250	271	280.8333	29.07931
120	272	272	320	272	272	278	358	265	272	275	250	260	280.5	29.47264
160	272	272	272	272	290	278	358	265	272	276	200	271	274.8333	34.25793
200	272	272	250	272	290	246	272	265	272	277	250	271	267.4167	12.75973
240	272	272	250	272	280	220		272		280		271	265.4444	19.13838
280	272									300			286	19.79899

B2

													Mean	Std Dev
0	272	272	272	272	272	272	272	272	272	272	272	272	272	0
40	272	272	275	272	272	272	272	272	272	272	272	272	272.25	0.866025
80	272	272	275	272	267	272	272	272	272	272	272	272	271.8333	1.749459
120	272	272	275	272	262	272	272	272	272	272	272	272	271.4167	3.088346
160	272	272	275	272	250	272	272	272	272	272	280	272	271.0833	7.05122
200	272	272	280	272	250	272	272	272	272	272	280	272	271.5	7.440674
240	272	272	280				272	280		272	280	272	275	4.140393
280			280								320		300	28.28427

APPENDIX R. SAMPLE CAPTURE.DAT

```
NAME SMC# A 2 1 40 R1  70
NAME SMC# A 2 1 40 R2  29
NAME SMC# A 2 1 40 R3  54
NAME SMC# A 2 1 40 G4  33
NAME SMC# A 2 1 40 G6  13
NAME SMC# A 2 1 40 R1  280
NAME SMC# A 2 1 40 G5  12
NAME SMC# A 2 1 40 R1  317
NAME SMC# A 2 1 80 R1  51
NAME SMC# A 2 1 80 R2  23
NAME SMC# A 2 1 80 R3  55
NAME SMC# A 2 1 80 G4  22
NAME SMC# A 2 1 80 G5  10
NAME SMC# A 2 1 80 G6  13
NAME SMC# A 2 1 80 R1  332
NAME SMC# A 2 1 80 R1  320
NAME SMC# A 2 1 120 R1  36
NAME SMC# A 2 1 120 R2  29
NAME SMC# A 2 1 120 R3  60
NAME SMC# A 2 1 120 G6  15
NAME SMC# A 2 1 120 G5  5
NAME SMC# A 2 1 120 G4  31
NAME SMC# A 2 1 120 R1  218
NAME SMC# A 2 1 160 R1  15
NAME SMC# A 2 1 160 G6  10
NAME SMC# A 2 1 160 R3  4
NAME SMC# A 2 1 160 R2  20
NAME SMC# A 2 1 160 R3  25
NAME SMC# A 2 1 160 G6  11
NAME SMC# A 2 1 160 R1  93
NAME SMC# A 2 1 200 R1  24
NAME SMC# A 2 1 200 R2  25
NAME SMC# A 2 1 200 R3  20
NAME SMC# A 2 1 200 G6  45
NAME SMC# A 2 1 200 G5  6
NAME SMC# A 2 1 200 R1  124
NAME SMC# A 2 1 240 R1  18
NAME SMC# A 2 1 240 R2  20
NAME SMC# A 2 1 240 R3  43
NAME SMC# A 2 1 240 G4  16
NAME SMC# A 2 1 240 G6  90
NAME SMC# A 2 1 240 R1  203
NAME SMC# A 2 1 280 R1  30
NAME SMC# A 2 1 280 R2  31
NAME SMC# A 2 1 280 R3  14
NAME SMC# A 2 1 280 G6  14
NAME SMC# A 2 1 280 G4  13
NAME SMC# A 2 1 280 R1  278
NAME SMC# A 2 1 320 R1  26
NAME SMC# A 2 1 320 G5  7
NAME SMC# A 2 1 320 R3  8
NAME SMC# A 2 1 320 R1  13
```

APPENDIX S. SAS PROGRAM FILES

PERFDEMO.SAS:

```
libname dataname "/tmp_mnt/h/sagan_u0/clswett/sas/";
options pagesize=58  linesize=80;
title "Performance and Demographic data for all subjects";
data dataname.dat;
infile "~clswett/sas/perfdemo.dat";
input lname $ smc $ project $ goals $ order $  fncost fnsked fnerr
     fnerg fnerd fneres fnprdt fnqamd fntrmd fnrwmd
  #2 smc $ project $ goals $ order $  Q1S Q1Q Q1C Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12
     Q13 Q14 Q15 Q16 Q17 Q18 curric $ age sex $ wkexp edago cfam chrswk grade;

/*
if (project='B') then delete;
if (project='A') then delete;
*/

/*
if (lname='Callagha') then delete;
*/

proc sort;
  by project goals  ;

proc print;

proc means;  by project goals ;

proc glm;
 class  goals   ;
 model fncost fnsked fnerr fnerg fnerd fneres fnprdt
      fnqamd fntrmd fnrwmd Q1S Q1Q Q1C Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15
Q16 Q17 Q18 age wkexp edago cfam chrswk grade = goals ;

 run;
```

DEMOCORR.SAS:

```
libname dataname "/tmp_mnt/h/sagan_u0/clswett/sas/";
options pagesize=58  linesize=80;
title "Correlation of all Demographics with Final outcomes for all subjects";
data dataname.dat;
infile "~clswett/sas/perfdemo.dat";
input lname $ smc $ project $ goals $ order $  fncost fnsked fnerr
    fnerg fnerd fneres fnprdt fnqamd fntrmd fnrwmd
  #2 smc $ project $ goals $ order $  Q1S Q1Q Q1C Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12
    Q13 Q14 Q15 Q16 Q17 Q18 curric $ age sex $ wkexp edago cfam chrswk grade;

/*
if (project='B') then delete;
if (project='A') then delete;
*/

/*
if (lname='Callagha') then delete;
*/

proc sort;
 by project goals  ;

proc corr; by project goals ;
var fncost fnsked fnerr grade;

proc corr; by project goals ;
var fncost fnsked fnerr edago;

proc corr; by project goals ;
var fncost fnsked fnerr wkexp;

proc corr; by project goals ;
var fncost fnsked fnerr chrswk;

proc corr; by project goals ;
var fncost fnsked fnerr age;

 run;
```

PROCESS.SAS:

```
libname dataname "/tmp_mnt/h/sagan_u0/clswett/sas/";
options pagesize=58  linesize=80;
title "Repeated measures analysis on Process data.";
title2 "Staffing Level for Group A";
/* This is run four times keeping the variables staff, qc, cost, duration*/

data dataname.dat (keep= lname $ smc $ project $ goals $ order $ time $
                    staff );
infile "/tmp_mnt/h/sagan_u0/clswett/sas/process.dat";
input lname $ smc $ project $ goals $ order $ time $ var1-var26 staff
    qc cost duration;
/*Run all variables for Project A then for Project B*/
/*
if (project='B') then delete;
*/
if (project='A') then initcost=944;
if (project='A') then initsked=272;

proc sort data=dataname.dat out=dataname.sort;
 by project goals lname time ;

proc transpose data=dataname.sort out=dataname.trans
/* (rename=(_0.00=y1 _40.00=y2 _80.00=y3 _120.00=y4 _160.00=y5 _200.00=y6
       _240.00=y7))*/;
  by goals lname;
   id time;

 proc glm data=dataname.trans;
  class goals  ;
  model  _0D00  _40D00  _80D00  _120D00 _160D00 _200D00 _240D00
     = goals/nouni;

  means goals /scheffe;
   repeated period /*polynomial /short summary*/;
 proc means;
  var  _0D00   _40D00 _80D00 _120D00  _160D00 _200D00 _240D00;
   by goals;
run;
```

LIST OF REFERENCES

Abdel-Hamid, T.K., "The Dynamics of Software project Staffing: A system Dynamics Based Simulation Approach," *IEEE Transactions on Software engineering*, vol. 15, no. 2, Feb. 1989.

Abdel-Hamid, T.K., and Madnick, S.E., "Lessons Learned from Modeling the Dynamics of Software Development," *Communications of the ACM*, vol. 32, no. 12, Dec. 1989.

Boehm, B.W., *Software Engineering Economics*, Englewood Cliffs N.J.:Prentice-Hall Inc., 1981.

Daniel, W.W., and Terrell, James C., *Business Statistics*, Boston:Houghton Mifflin Company, 1975.

Remus, William, "Graduate Students as Surrogates for Managers in Experiments on Business Decision Making," *Journal of Business Research*, vol. 14, 1986.

Weinburg, G. M. and E. L. Schulman, "Goals and Performance in Computer Programming," *Human Factors*, vol. 16, 1974, pp. 70-77.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22304-6145	2
2.	Library, Code 52 Naval Postgraduate School Monterey, California 93943-5002	2
3.	Dr. Tarek K. Abdel-Hamid, Code SM/AH Department of Systems Management Naval Postgraduate School Monterey, California 93943-5000	10
4.	Dr. Kishore Sengupta, Code SM/SE Department of Systems Management Naval Postgraduate School Monterey, California 93943-5000	2
5.	Curricular Officer, Code 36 Department of Systems Management Naval Postgraduate School Monterey, California 93943-5000	5
6.	Clinton L. Swett 1006 "E" Street Fairbury, Nebraska 68352	2